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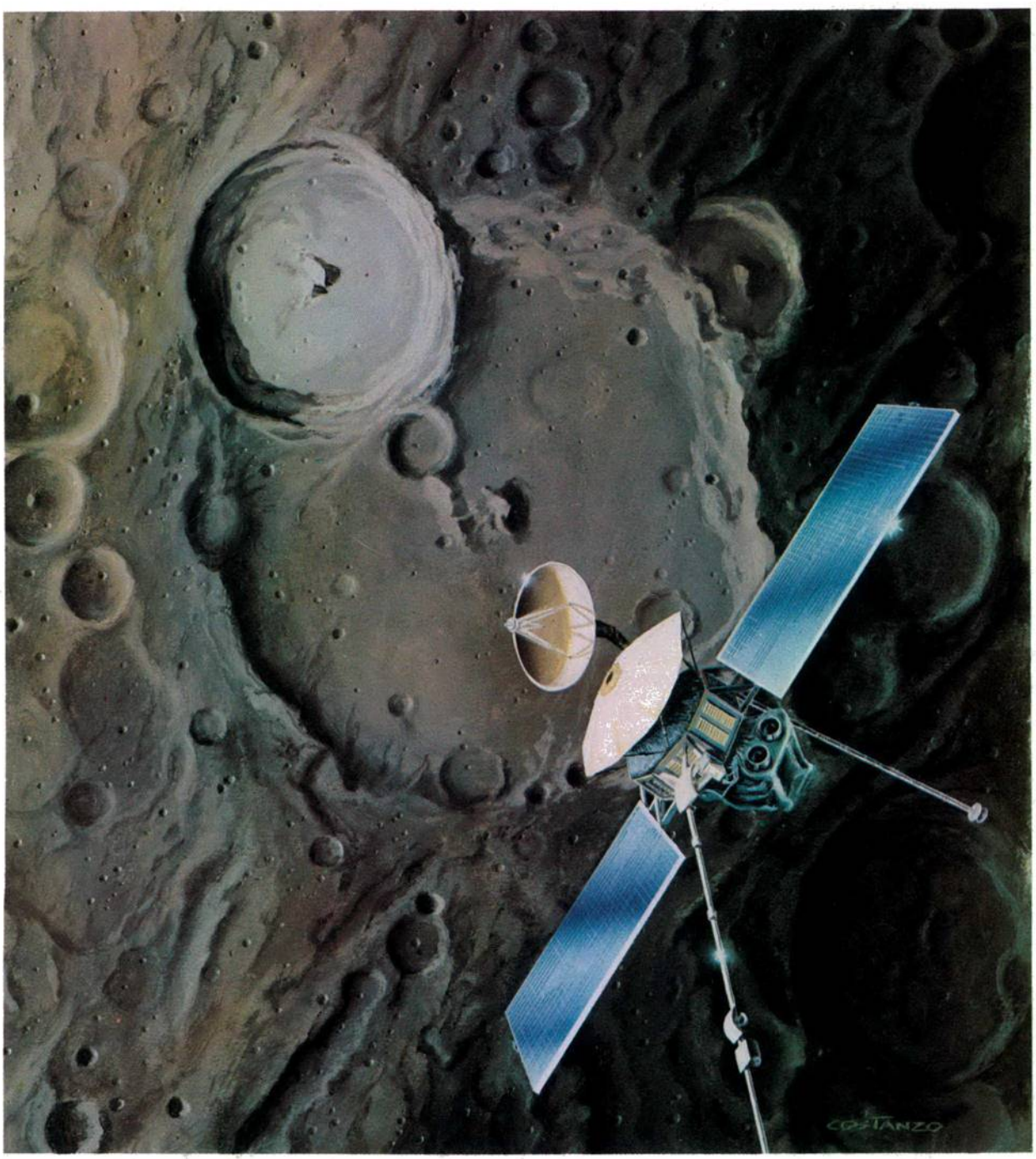

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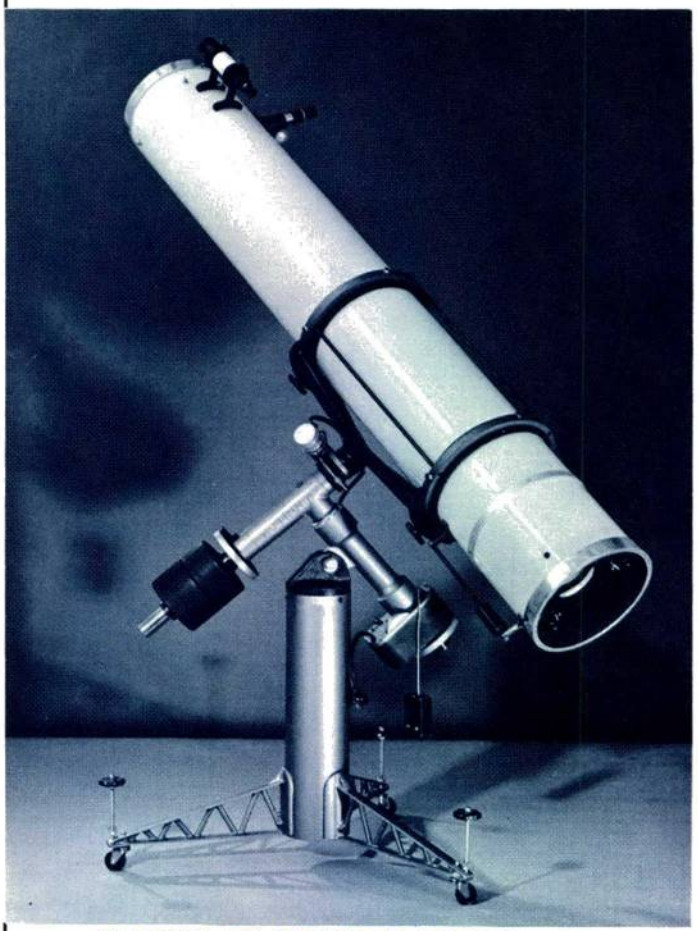

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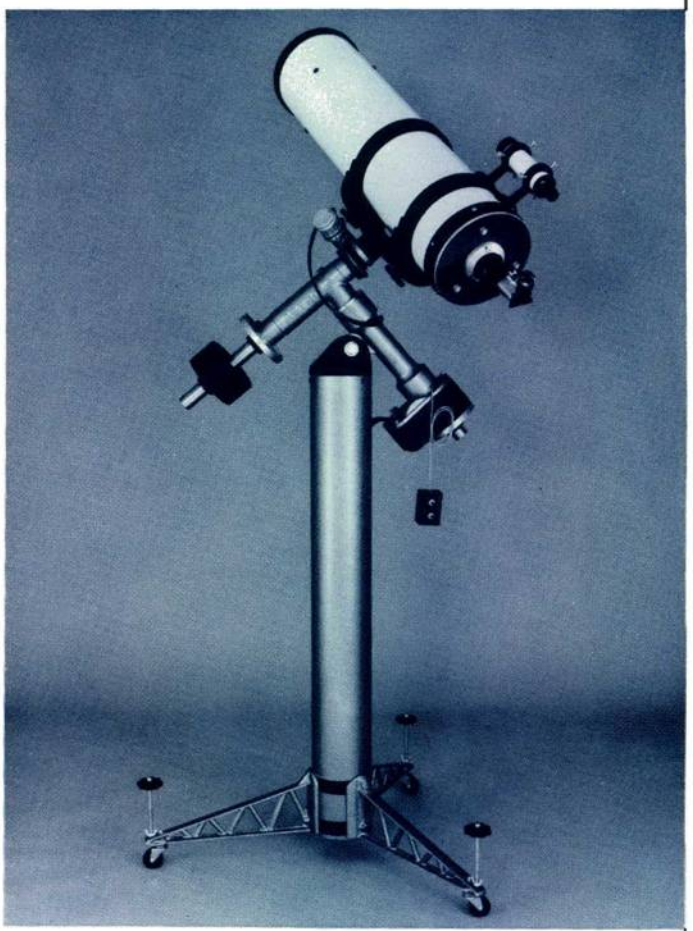

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Artwork by Victor Costanzo

The large bright crater to the upper right was one of the first features observed by Mariner 10 as it hurtled toward Mercury on a mission to provide man's first detailed view of that planet. The Mariner Television-Science Team has proposed the name "Kuiper" for this 25 mile diameter feature. Gerard P. Kuiper, a prominent planetary scientist and member of the TV team, died Dec. 23, 1973 while the spacecraft was en route to Venus and Mercury. The features shown in this detailed rendering can be located just above center in the photo on page 7.

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Planetary Bonanza

If there were a surviving picture of the moon drawn in the sand of a tropical beach a million years ago by our ancestors, that picture would probably have shown more detail than the best image of the planet Mercury seen by the most experienced eye using the world's greatest telescope. Never in the history of the exploration of the solar system has so much been learned so fast about such a poorly known object.

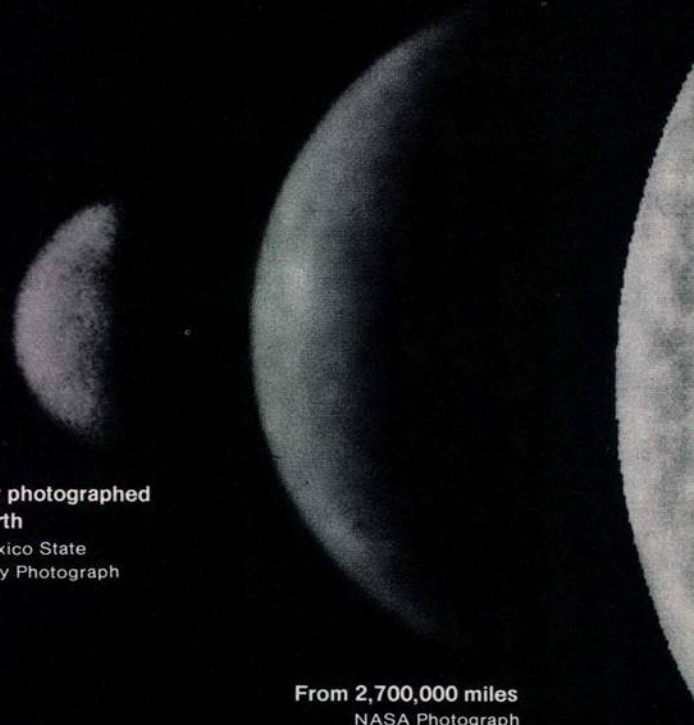
Another three month long period of dazzling sunshine is beginning for this region of the planet Mercury — a planet whose lunarlike surface has come under the probing eye of man's first spacecraft to the inner planet. The sun is less than 10 degrees above the horizon and already the temperature is well above the boiling point of water. Only 29 million miles away the sun blazes with 10 times the intensity felt on Earth. Fine dustlike particles that trace the plane of the solar system reflect the sun's light producing the faint glowing spikes on either side of our star. The glow immediately around the sun is its atmosphere, the corona. Artwork by Victor Costanzo

It all happened within a few days in late March, 1974 when the probing eyes of the interplanetary traveler Mariner 10 viewed the cratered surface of the solar system's inner planet and sent those images streaking back to Earth at the speed of light. Reconstructed by computers at NASA's Jet Propulsion Laboratory at Pasadena, Calif., the photographs revealed for the first time the true face of our third nearest planetary neighbor.

Mercury is a cratered world scarred by billions of years of bombardment, just as our moon has been. Basically Mercury looks like the moon. It's only half again greater in diameter and a midget compared to Earth, so the craters were not unexpected. But there were findings in the historic mission that did come as a surprise.

Before we examine the Mercury findings in detail, we should put the last half year of planetary exploration into perspective. It is, as Carl Sagan says on page 22, "a very special time". We have been able to see, for the first time, exquisite detail in the cloud veils of Jupiter and Venus, and the barren plains of Mercury. And with the Soviet Mars 5 in orbit about the red planet we are receiving pictures from that planet as well (see Astro-News) making an almost simultaneous planetary bonanza.

On these pages, ASTRONOMY presents a pictorial essay of planetary vistas unknown less than a year ago. Never before and probably never again in the history of planetary exploration will so much new information hit us at the same time. The preliminary exploration of Jupiter, close-up studies by flyby of Mercury and Venus, and continued reconnaissance of Mars — all at once this is a rare package. The future undoubtedly holds more surprises but we can hardly expect so much new information about so many planets to be available within such a short period. Let's now examine the findings of the various missions as analyzed by the team of scientists that made up the investigation troop that followed the interplanetary robots from conception to encounter.



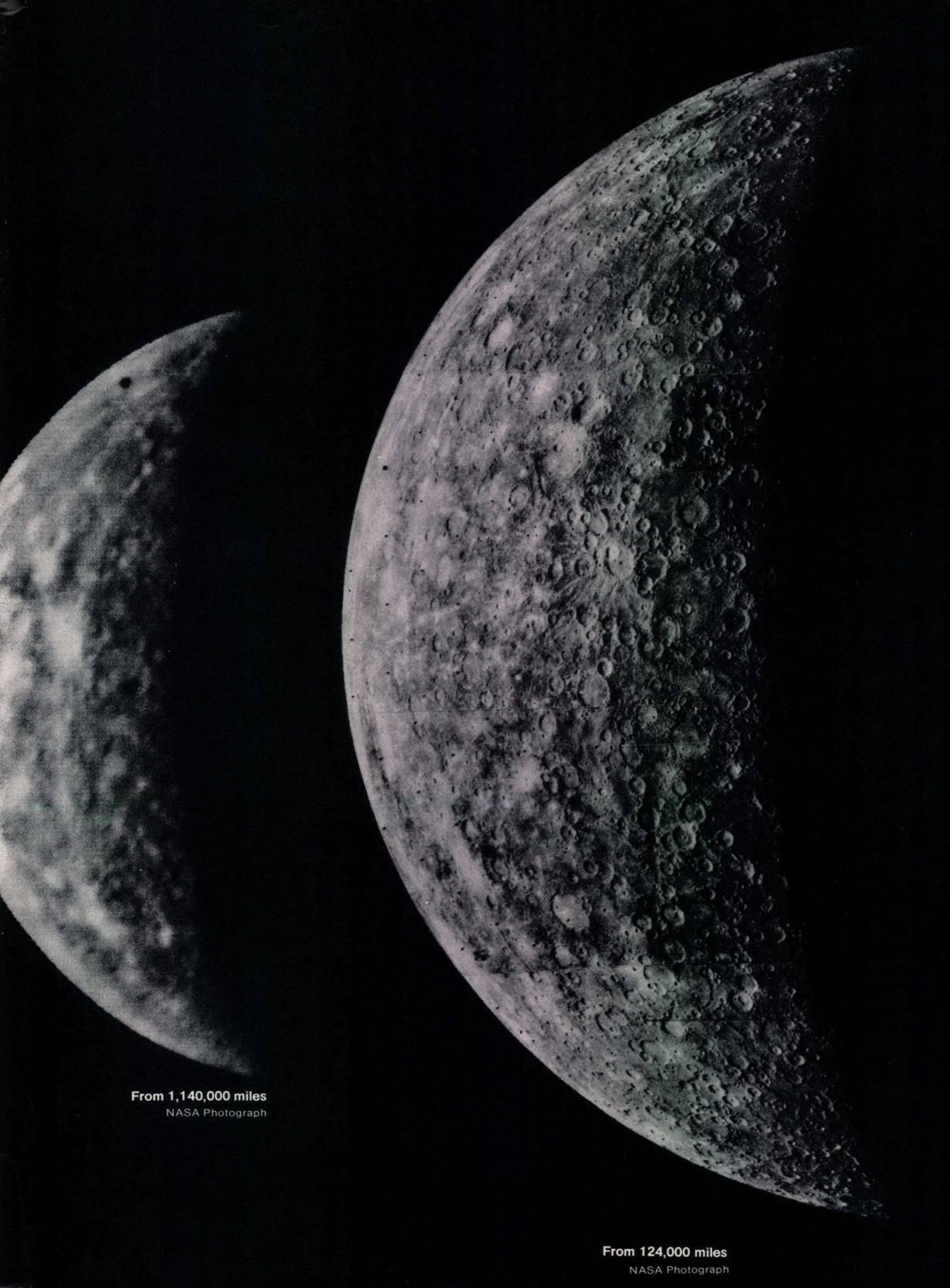
Mercury photographed from Earth
New Mexico State University Photograph

From 2,700,000 miles
NASA Photograph

Mercury

The sun's nearest and smallest planet "looks just like the moon" said Bruce Murray of the California Institute of Technology and leader of the team of scientists analyzing Mariner 10's photos. Murray was gazing intently at the same photos that are displayed on these pages yet he and other planetary scientists were fully aware that Mercury is not like the moon in its basic composition. The moon is 3.3 times as dense as water whereas

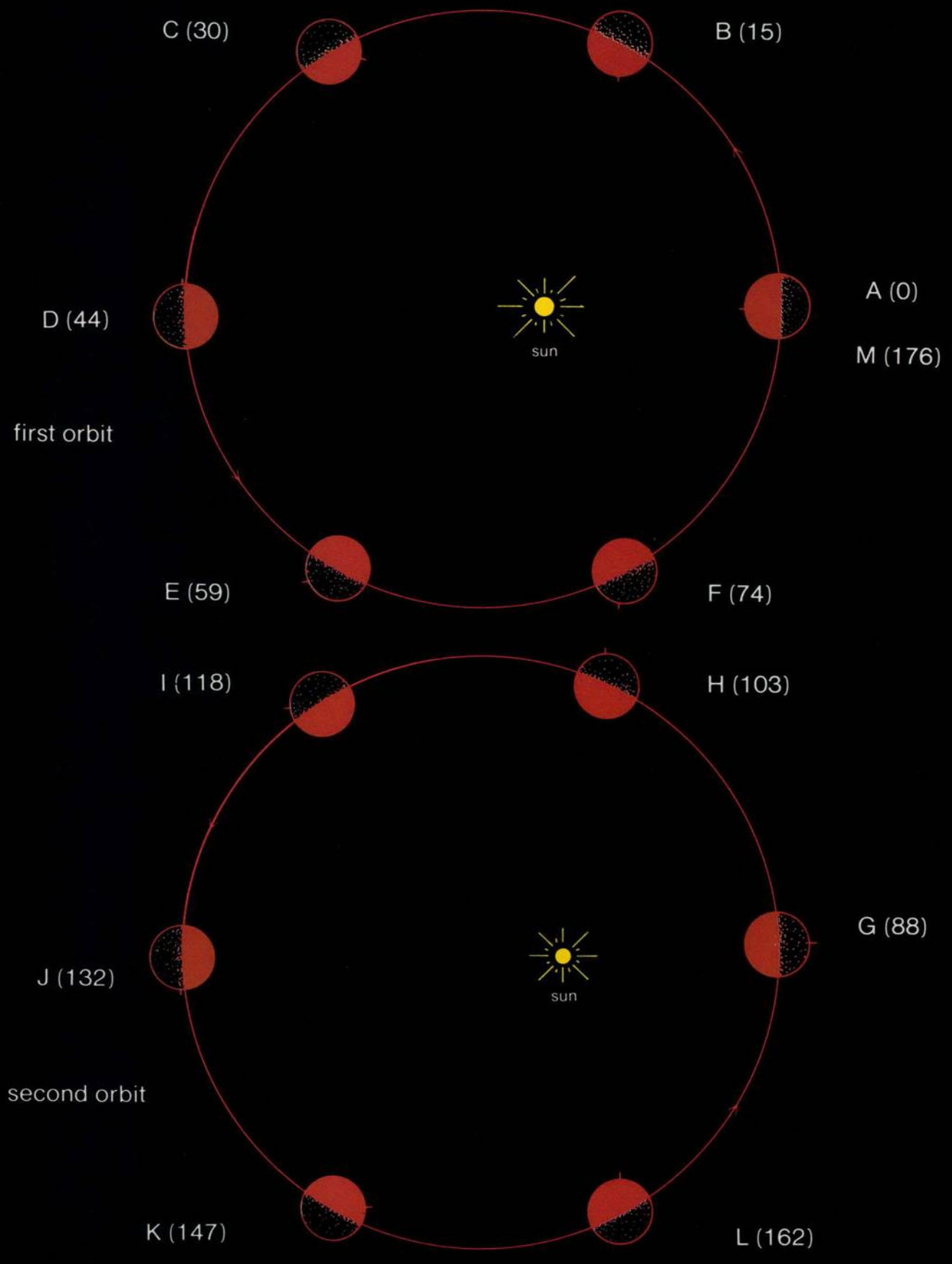
The battered surface of Mercury — a landscape that has remained essentially unchanged since the dawn of the solar system — was seen for the first time by Mariner 10. The photo at extreme left is one of the few pictures taken from Earth that discerns anything at all on the planet. Even Mariner's early pictures improved on this best effort. In the mosaic of 18 pictures (right) the surface is blanketed with craters up to about 150 miles in diameter.



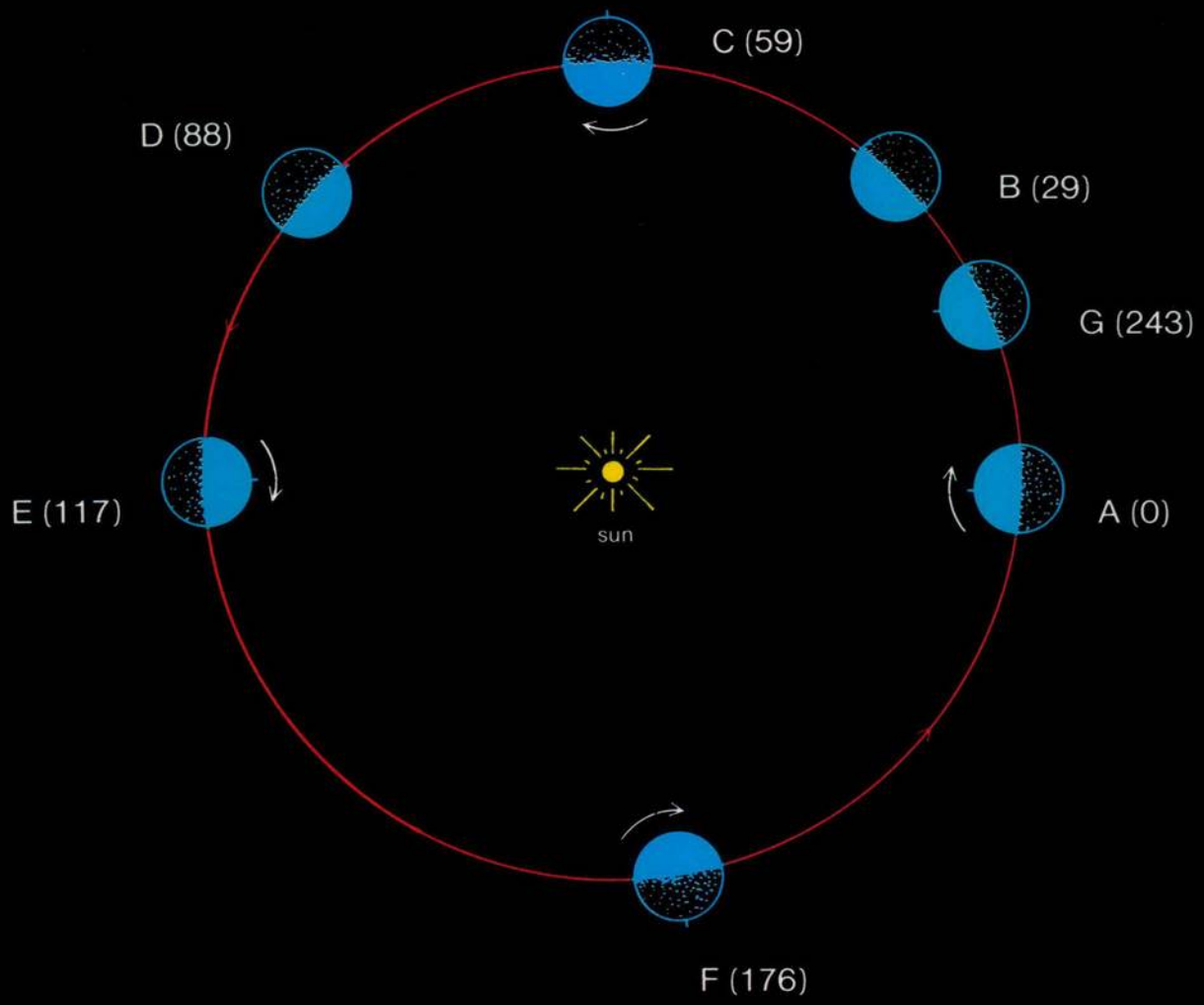
From 1,140,000 miles
NASA Photograph

From 124,000 miles
NASA Photograph

MERCURY'S 176 DAY ROTATION



VENUS' 117 DAY ROTATION

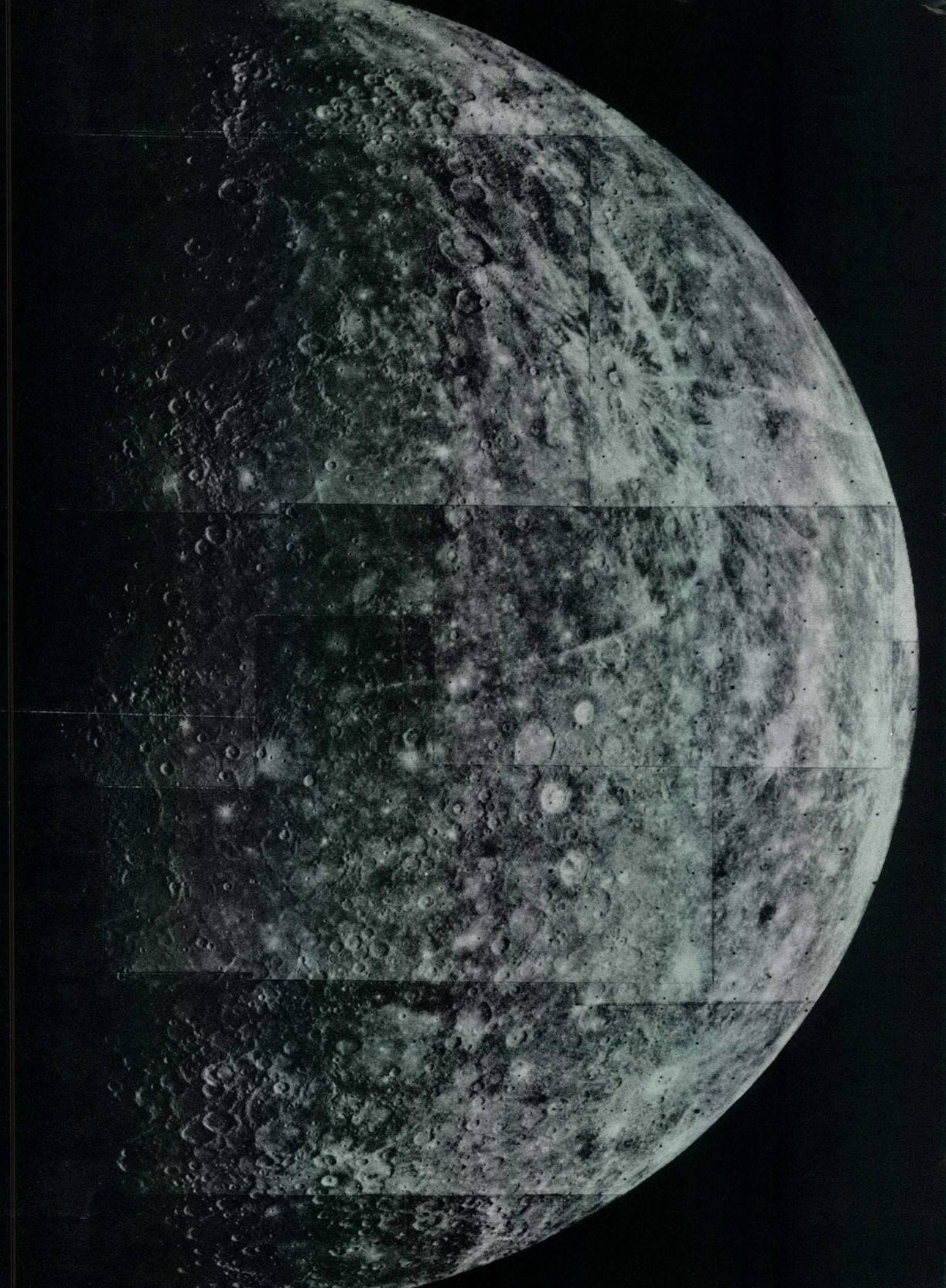


Mercury Rotation

The rotation period for Mercury quoted most often is 59 days, but this is the period of time the planet rotates with reference to the fixed stars. More useful is the 176 day rotation period from one noon to the next. The small bar marks a fixed spot on Mercury for reference. Start at A with the sun overhead at the marked spot. By B, the counterclockwise rotation of the planet has carried it 90 degrees, but the sun is still nearly overhead because Mercury has advanced in its orbit. By C the planet has actually turned 180 degrees, but the sun will have seemed to move only about 60 degrees. Continue on to E where we reach the 59 day rotation period. Note that the planet has actually rotated once but has only turned 1/3 of the way around with reference to the sun. Continuing on through to M we are finally back to where we started with the sun seen overhead — yet Mercury has actually rotated three times on its axis. So despite its so-called 59 day rotation, Mercury has a true "day" in 176 Earth days. Mercury's orbit is quite elliptical, taking the planet to within 28 million miles of the sun (A and G) and out as far as 43 million miles (D and J). The sun's tidal force is probably responsible for "locking" Mercury into a rotation situation that brings the same point back to face its master every two revolutions.

Venus Rotation

Venus, like Mercury, has a very long rotation period. The textbook period is 243 days, but this refers to its rotation with reference to the fixed stars. If you follow from A to G you will see the marker (which indicates a fixed point on the planet) move around once. But you only have to go from A to E to get from one noon to the next. Unlike Mercury, Venus' clockwise (retrograde) rotation adds to the orbital motion. (Numbers in parentheses in both diagrams are elapsed time in Earth days.)



Mercury is 5.5 times as dense — by far the densest object of its size in the solar system.

John S. Lewis, an internationally recognized authority on planetary structure, predicted that the 3,030 mile wide planet should have a core of iron-nickel alloys (similar to Earth's core) about 1,800 miles in diameter, which is overlain by material similar to the lighter type rocks of which the moon is almost entirely composed. According to Murray, the Mariner 10 data bears this out. The surface of Mercury does not look much different from the moon because that surface material probably is, in fact, basically like the lunar surface. There is nothing in the Mariner data or in observations from Earth that indicates otherwise.

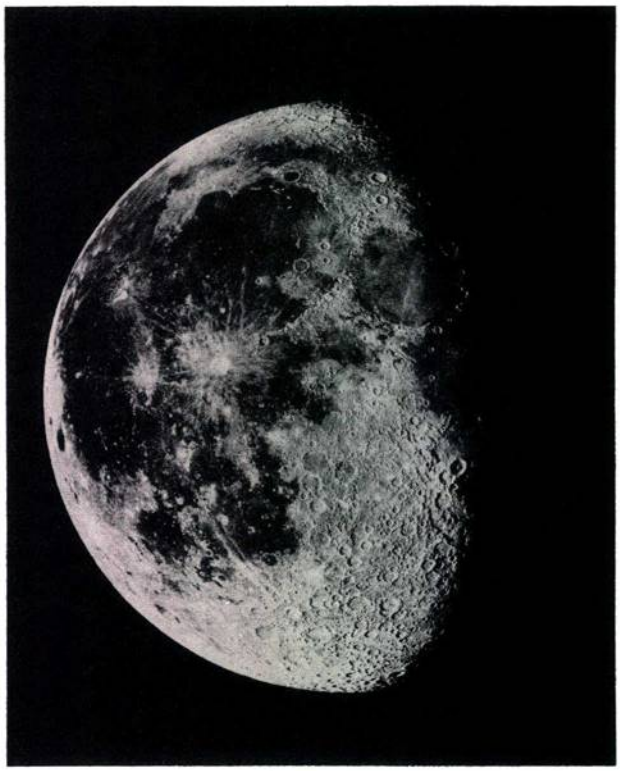
However the interior of Mercury, being so different from the moon and much more earthlike by having a metallic nickel-iron core of large dimensions, provides planetary astronomers with something of a paradox. Murray commented on that problem, saying that the craters visible in the Mariner 10 photos almost certainly date from near the origin of the solar system, 4 to 4-1/2 billion years ago. "This implies," he said, "that there have not been any internal activities that have shaped the surface features since that time."

"That's a profoundly significant conclusion," he remarked, adding that it means the chemical differentiation that led to the silicates on the outside and an iron core on the inside must have been completed in the first few hundred million years of the planet's existence. No other known body in the solar system has these circumstances associated with it.

So it seems that some rethinking about the formation of planets will be required to explain how Mercury's dense core and lighter surface layers got separated within the first hundred million years of the planet's formation.

Another face of Mercury, markedly different from the one seen on page 7 , is a combination of 18 pictures taken by Mariner 10 at a distance of 130,000 miles, six hours after the spacecraft flew past the planet on March 29. A large circular basin some 800 miles in diameter near the terminator (left center) is strikingly similar to the lunar "seas". This area of the planet is just coming into sunlight as Mercury slowly rotates. The planet's north pole is at the top and the equator extends from left to right about two-thirds down from the top. Earthbound telescopic observers recorded Mercury's darkest features in this region near the terminator, north of the equator. This zone is centered around 200 degrees on the map on page 56. Bright rays are centered on craters gouged by relatively recent impacts of asteroids or comets, although one large curving white arc (upper right) is not typical of ray structure. The bright crater with the central peak (near bottom) and faint ray system is similar in size and form to Tycho, the 56 mile wide lunar crater shown in the photo on this page. Wrinkles seen near the terminator are similar to lunar "flow ridges" and are assumed to have been molten at one time, probably during the first 10 percent of Mercury's existence.

NASA Photograph

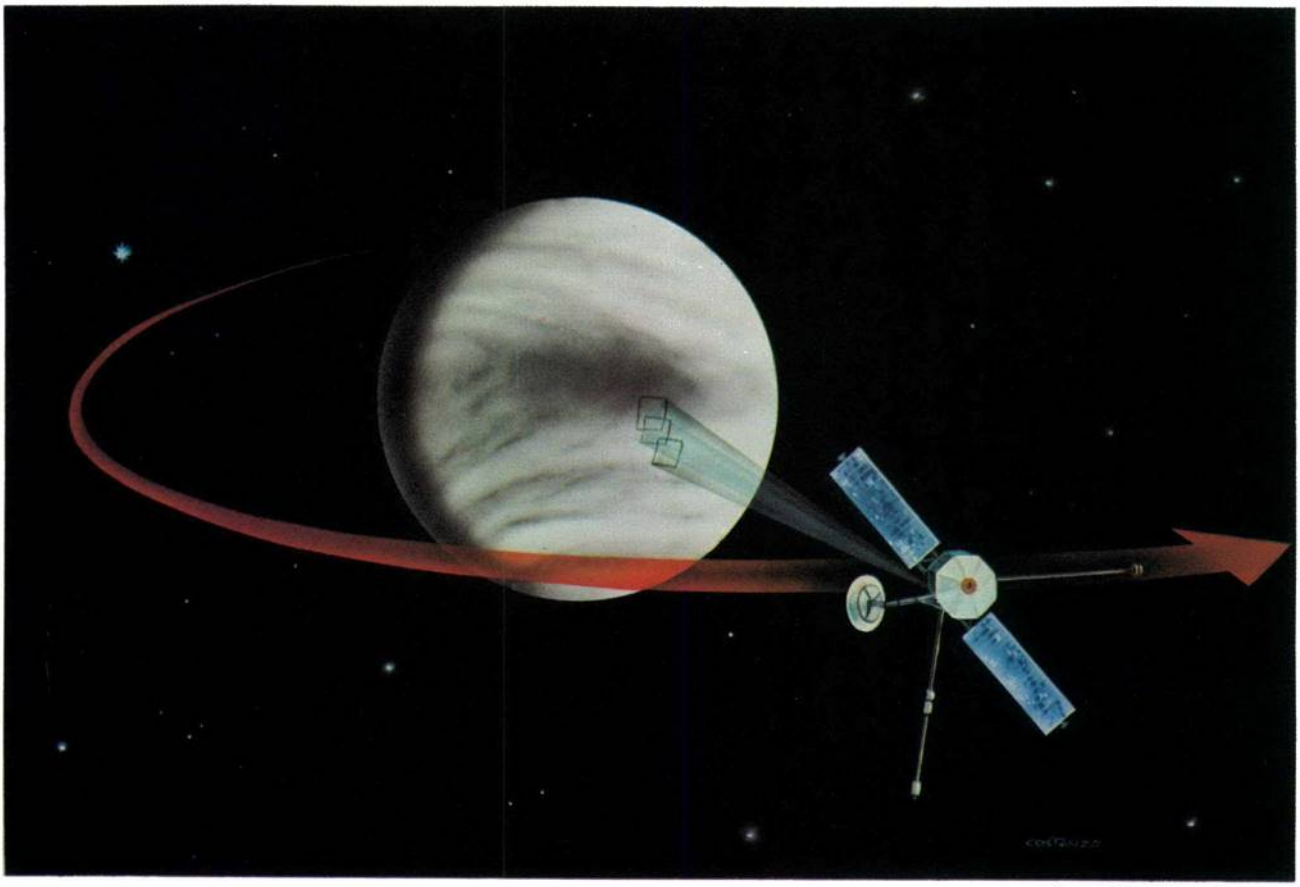


Lick Observatory Photograph

This photo of the moon shows the similarity between our satellite and the planet Mercury. Both worlds have craters that average the same approximate size and age; Mercury's craters look smaller because of the planet's larger size. The lunar crater Tycho is the center of a bright ray system near the bottom of the photo. The "wrinkles" seen in the photo opposite are seen on the lunar flatlands near the terminator.

But let's get back to the similarities to the moon which are readily apparent. Craters abound, overlapping each other, splattering the surface, especially on the crescent Mercury viewed on the way in (page 7). That face contrasts with the less cratered terrain on the outward part of the mission where Mercury has major mare areas (page 10). A similar situation exists on our moon. The side of the moon that faces Earth has several major, darker, so-called seas or mare, but the far side of the moon has virtually none of these features. Since the same kind of asymmetry exists on Mercury, the question of why the moon has one side so much different from the other now applies to Mercury as well.

However, it is important to keep in mind that we have only viewed about 45 percent of the planet from Mariner 10. The area on the bright limb on both the inbound and outbound portions of the mission was not well seen, nor was the 50 percent of the planet that was in darkness. A future mission to pick up the side in darkness, the poles and the part directly facing the sun will be part of any future probes of the smallest planet.



Artwork by Victor Costanzo

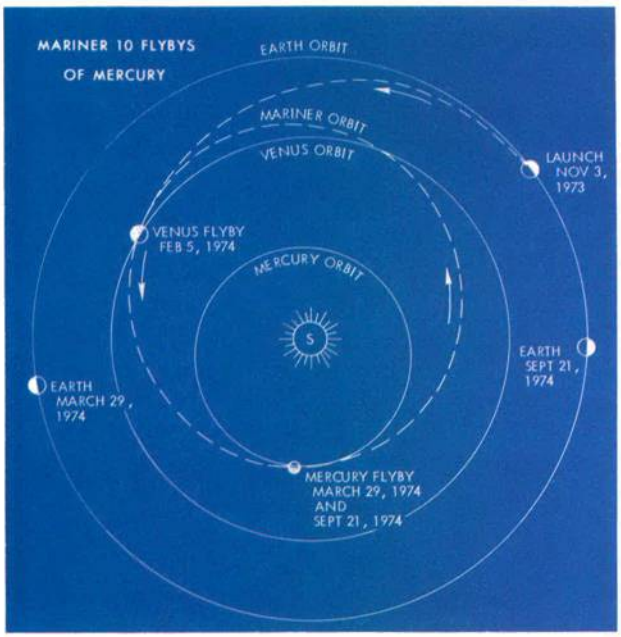
Soon after Mariner 10 hurtled past the night side of Venus on Feb. 5, the illuminated side of the planet came into view. The spacecraft's twin cameras recorded thousands of pictures of the never-before-seen details of the planet's cloud structure. Visible only in ultraviolet light, the clouds (shown here) were only vaguely recorded in Earth based telescopes.

A future flight to Mercury has been tentatively planned by NASA for 1987. That mission will likely be an orbiter similar to Mariner 10 but with the addition of braking rockets to put it into orbit around the planet. An orbiter with a lifetime of at least three months would be required to properly map the entire planet. To get all the possible viewing angles of the various surface features, an orbiter that could continue working for six months (two Mercury orbits) would be desirable since it would allow coverage of the planet throughout the 176 day rotational period. Murray recently suggested using the Mariner 10 back-up spacecraft sometime between now and the 1987 orbiter to fly by the side of the planet that was in darkness during the current mission.

Meanwhile, Mariner 10 is now swinging in an orbit around the sun that will carry it out past the orbit of Venus and then back in to meet Mercury on Sept. 21, hopefully to fly by the south pole of the planet giving a different perspective of the same side of Mercury that was seen on the first flyby. (The craft would be looking at the same side because Mercury would have completed a 176 day rotation by that time.)

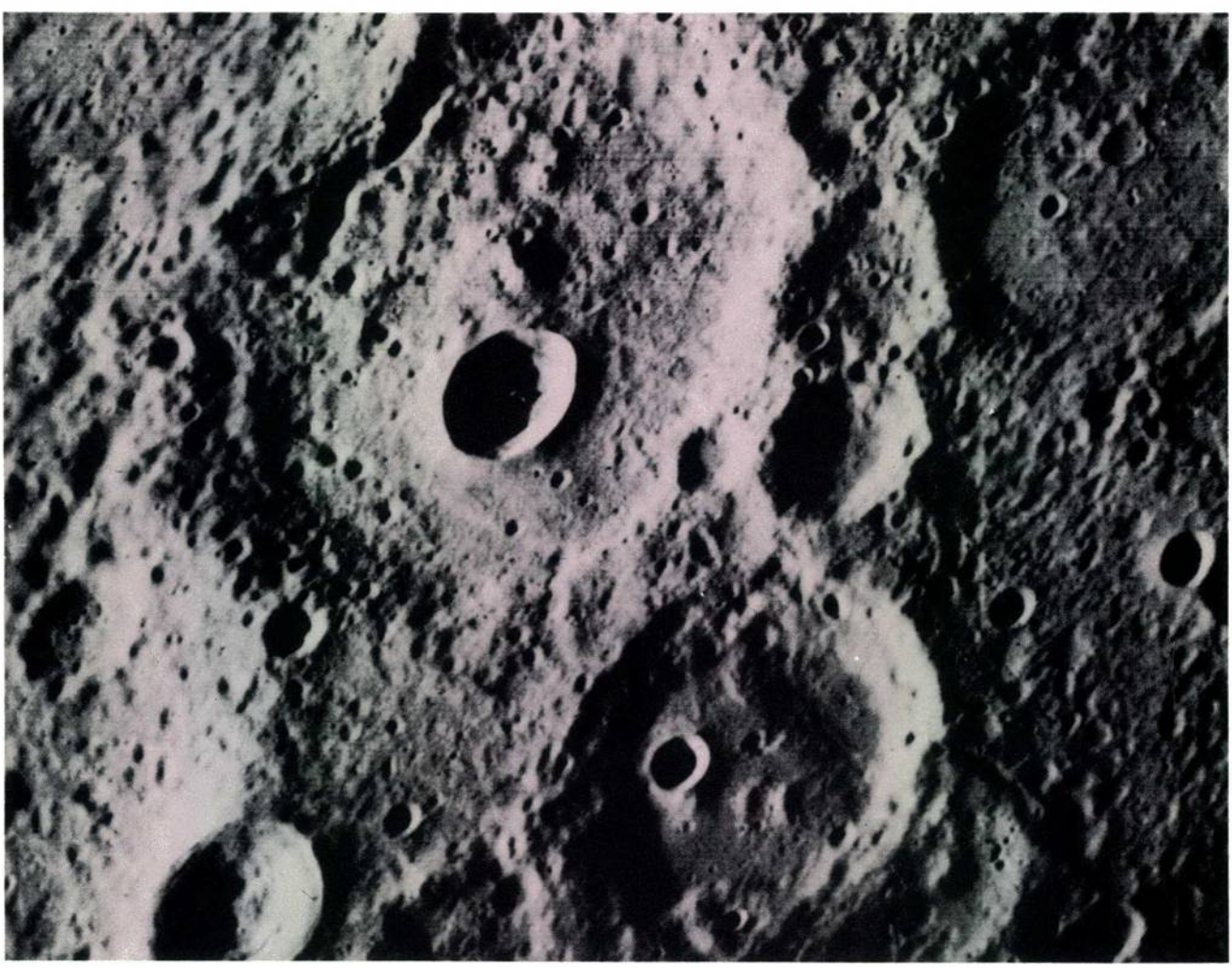
What about a Mercury atmosphere? The search for an atmosphere has been going on for over a century. During its fairly infrequent transits in front of the sun, Mercury was seen to have a very sharp edge when viewed against the solar disk, thus implying no atmosphere or a very thin blanket of gases. Visually the surface of Mercury showed features that remained essentially the same for long periods of time (see Gazer's Gazette), so there was no indication of an atmosphere according to visual observers. But there are better ways of finding an atmosphere.

Using a spectroscope attached to a 50 inch telescope, Soviet astronomer Nikolai Kozyrev has, on several occasions, reported a moderately extensive hydrogen atmosphere enshrouding Mercury. Kozyrev reiterated his assertion about the hydrogen atmosphere only a few months ago and based it on new observations made in the Soviet Union. Although Mariner 10 did detect a trace of hydrogen in the very thin atmosphere of Mercury the level was far too low to possibly be detected



from Earth. The gases that were found in the extremely thin atmosphere (less than one-millionth as dense as Earth's) include helium, argon, neon and possibly xenon. These are decay elements from uranium and thorium which leads Mercury scientists to speculate that the inner planet has as much of these radioactive elements as does Earth.

Mariner 10 also detected a magnetic field stronger than that of Venus (which the same spacecraft's instruments were unable to detect). The field is strong enough to create a "bow shock front" that deflects much of the impinging solar wind. This was completely unexpected; it was believed that the solar wind bombarded the surface of Mercury. The field is about one-thousandth as strong as Earth's. What puzzled the investigators, particularly Norman Ness of NASA's Goddard Spaceflight Center who was in charge of this part of the mission, was the source of the magnetic field. The



NASA Photograph

A fresh crater in the center of an older crater basin is shown in this Mariner 10 Mercury photograph taken 12,860 miles from the planet. The "new" crater is about eight miles across.

The area seen in this photo can be found by careful examination of the terminator region just above center in the large photo on page 7 .

slow rotation of the planet would seem to rule out an internal mechanism, so Ness suggested that the interplanetary magnetic field flowing past the planet might generate the field.

Mercury had its temperature taken during the mission. At the terminator the temperature fell from about+350 degrees in low sunlight to -200 degrees just over the line in darkness. By dawn, three months later, the thermometer bottomed out at -300 degrees. Mariner didn't pass the high sun zones, but measurements made from Earth have reliably recorded high noon readings up to +800 degrees making the planet's temperature range the largest known in the solar system.

Venus

The planet that has shed little of its secrets for so many years finally divulged some unknowns to the probing eyes and instruments of Mariner 10. As reported in Astro-News in the April issue of ASTRONOMY, the cameras of Mariner did find out (at last) what the clouds of Venus really looked like. Only photos taken in invisible ultraviolet light recorded any features. If you were riding along with Mariner 10 you wouldn't have seen anything since the photos taken in visible light (showing the planet as it would be seen by your eyes) were blank — nothing but a featureless white ball.

With the ultraviolet filters in place, detailed cloud structures and violent turbulence in the upper layer of the Venus cloud deck were mapped. It appears that the topmost layer of clouds is roaring around the planet at over 250 m.p.h. They move in the same direction as the planet's rotation but they whip completely around Venus in only four days.

Just what the difference is between the dark and light areas recorded in photos is not quite clear — perhaps it's a difference in temperature or rising and falling zones of convection. But just why they are visible only in ultraviolet light remains puzzling.

While the mission was in its planning stages there was a strong suspicion that ultraviolet light would show something because photos from Earth in that wavelength have recorded blotches on the planet (see photo on page 18).

Mariner reported hydrogen as the major element in the cloud decks. According to Lyle Broadfoot, principal investigator for the ultraviolet experiment on the spacecraft, no deuterium was detected. This has important implications. If there is (or was) water on Venus, the atmosphere should be rich in deuterium because deuterium, being heavier than hydrogen, would be less likely to escape the planet's gravity and be lost to space. Thus, for water to enter into Venus' history, deuterium should have been detected. Since it wasn't, it seems the hydrogen that was observed comes from the unimpeded solar wind impinging directly on the atmosphere of Venus and not from the breakdown of water.

Michael McElroy of Harvard University has suggested that at Venus' distance from the sun, the hydrogen in the original nebula from which Venus and the other planets formed must have been driven away from the vicinity of Venus when it was in the early stages of its formation. With little original hydrogen there can be no water (H_2O), and therefore the hydrogen seen must be from the solar wind, said McElroy.

The intricate structure in the rapidly moving and swirling top cloud layer is probably not duplicated in the lower layers. The Mariner data suggests that there is not much mixing between layers — a sort of layer cake affair — with the top clouds 40 miles above the surface and an invisible major layer 20 to 30 miles up. This lower layer appears to be very dense according to analysis of signals from Mariner 10 that were transmitted through the clouds. Even if we could penetrate the

Ⓐ

Cratered terrain very similar to that on the moon is seen in this photo of Mercury taken by Mariner 10 on March 29 from a range of 19,300 miles. The large, flat-floored crater at right is about 62 miles in diameter — about the same size as the lunar crater Copernicus. Numerous small craters and linear grooves radial to the crater probably are ejecta thrown from the crater during its creation — presumably due to an impacting asteroid. NASA Photograph

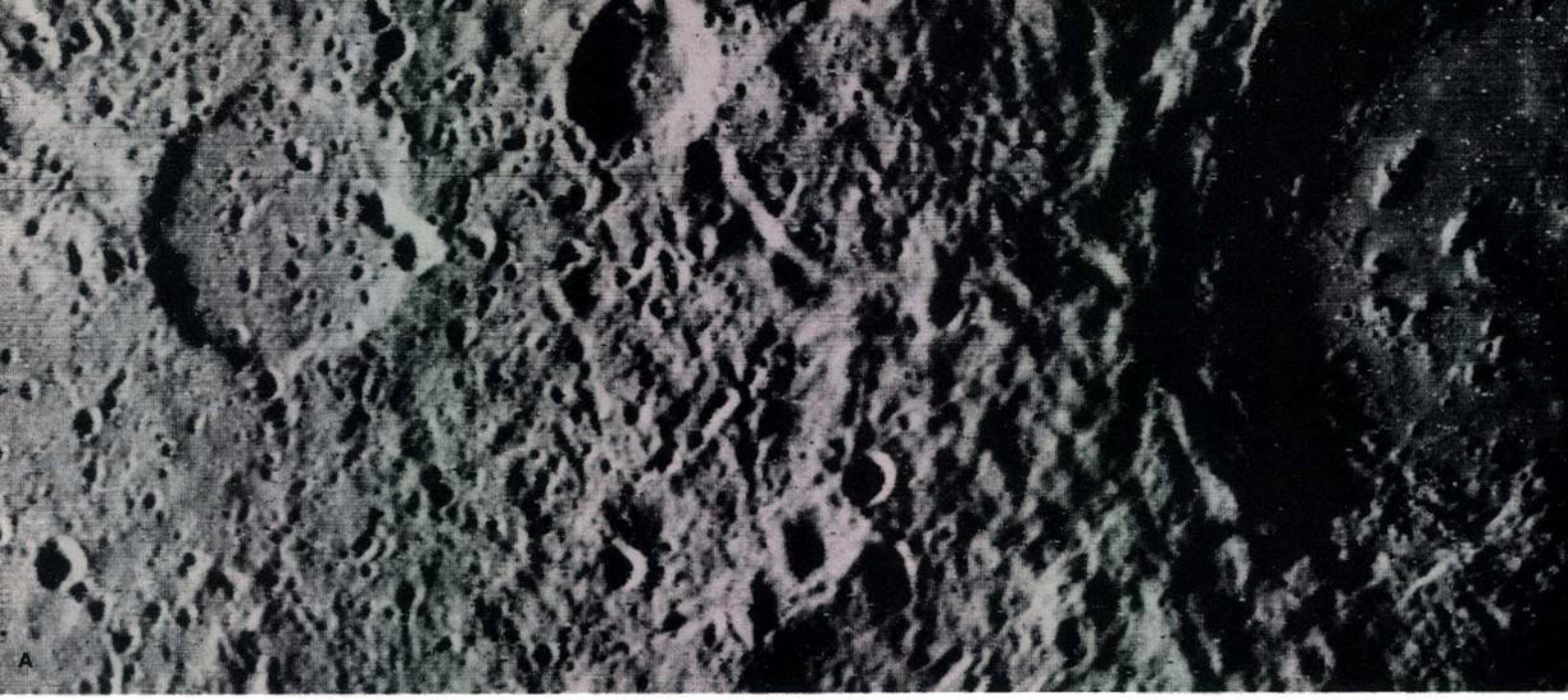
Ⓑ

A dark, smooth, relatively uncratered area on Mercury was photographed from a range of 54,000 miles two hours after Mariner 10 flew by the planet. Above and to the left of center is a surface similar to the mare material on Earth's moon. It embays and covers rougher, older, heavily cratered topography like that which can be seen in both upper corners of this picture. A history of heavy cratering seems to have been followed by volcanic filling, similar to the process on the moon. The prominent, sharp crater with a central peak (center) is 19 miles across. The bright six mile diameter "halo" crater to its right is a more recent feature caused by an impact that blasted off the sun-darkened surface layers exposing the lighter subsoils. Examination of the photo on page 10 will reveal these features just below center.

NASA Photograph

Ⓒ

Taken only minutes after Mariner 10 made its closest approach to the planet Mercury on March 29, this is one of the highest resolution pictures obtained during the mission. Craters as small as 500 feet across can be seen. The picture, taken from a distance of about 3,700 miles, measures about 30 by 25 miles. The relatively level surface contrasts with the abundant relief seen in some close-up views on the opposite side of the planet. The long, narrow area of hills and scarps to the left resembles ridges in the mare material of Earth's moon. Abundant craters in various stages of degradation dot the surface. NASA Photograph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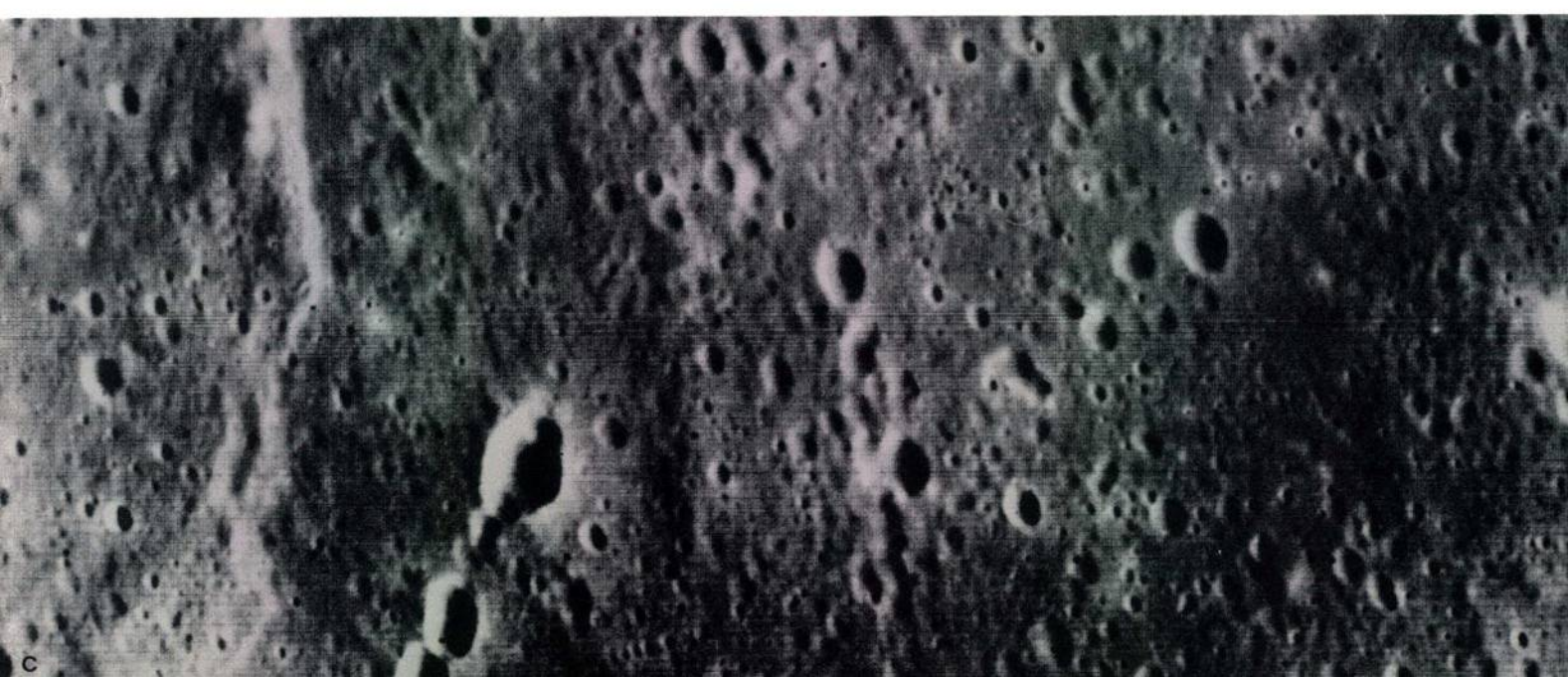
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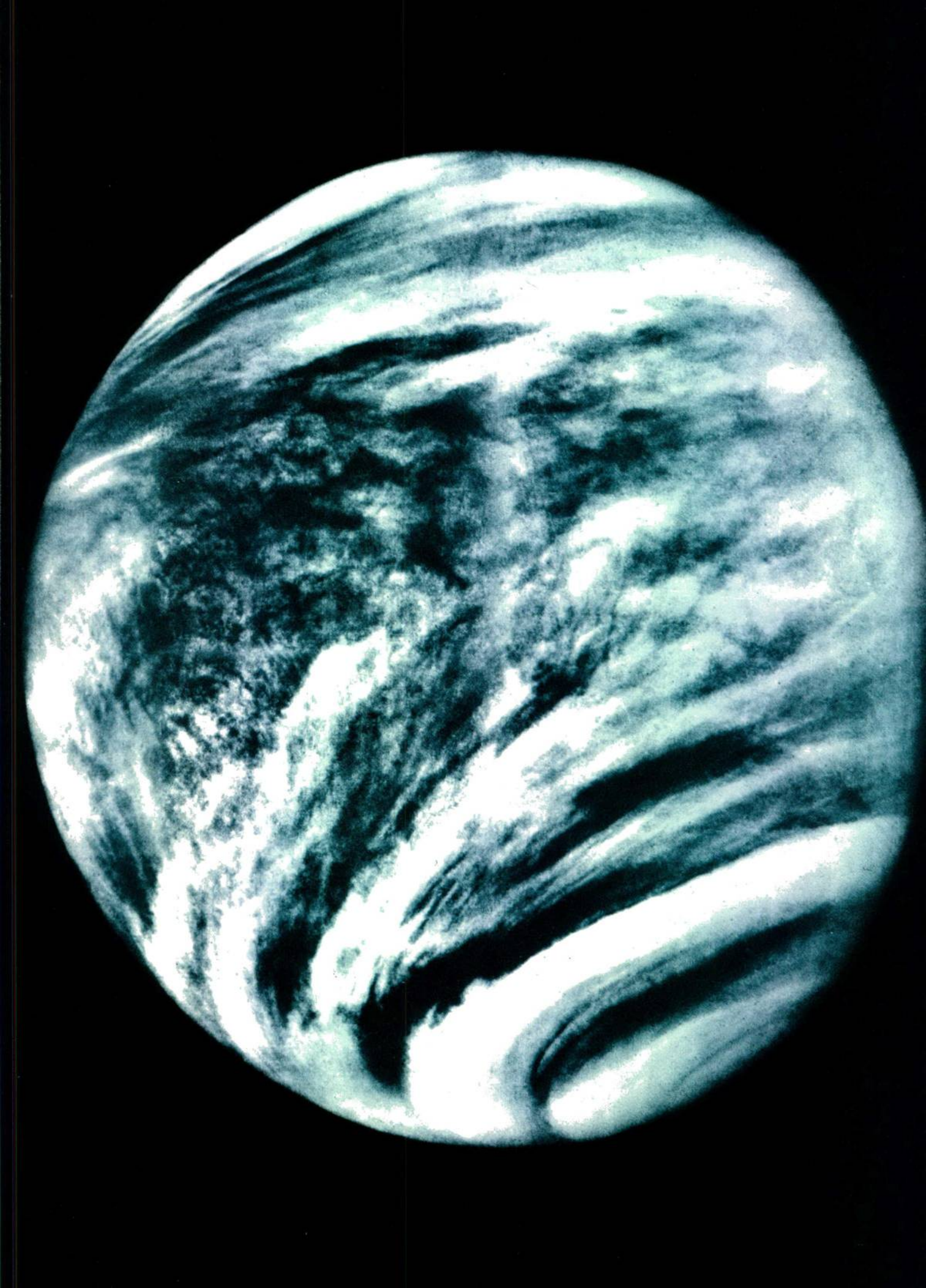
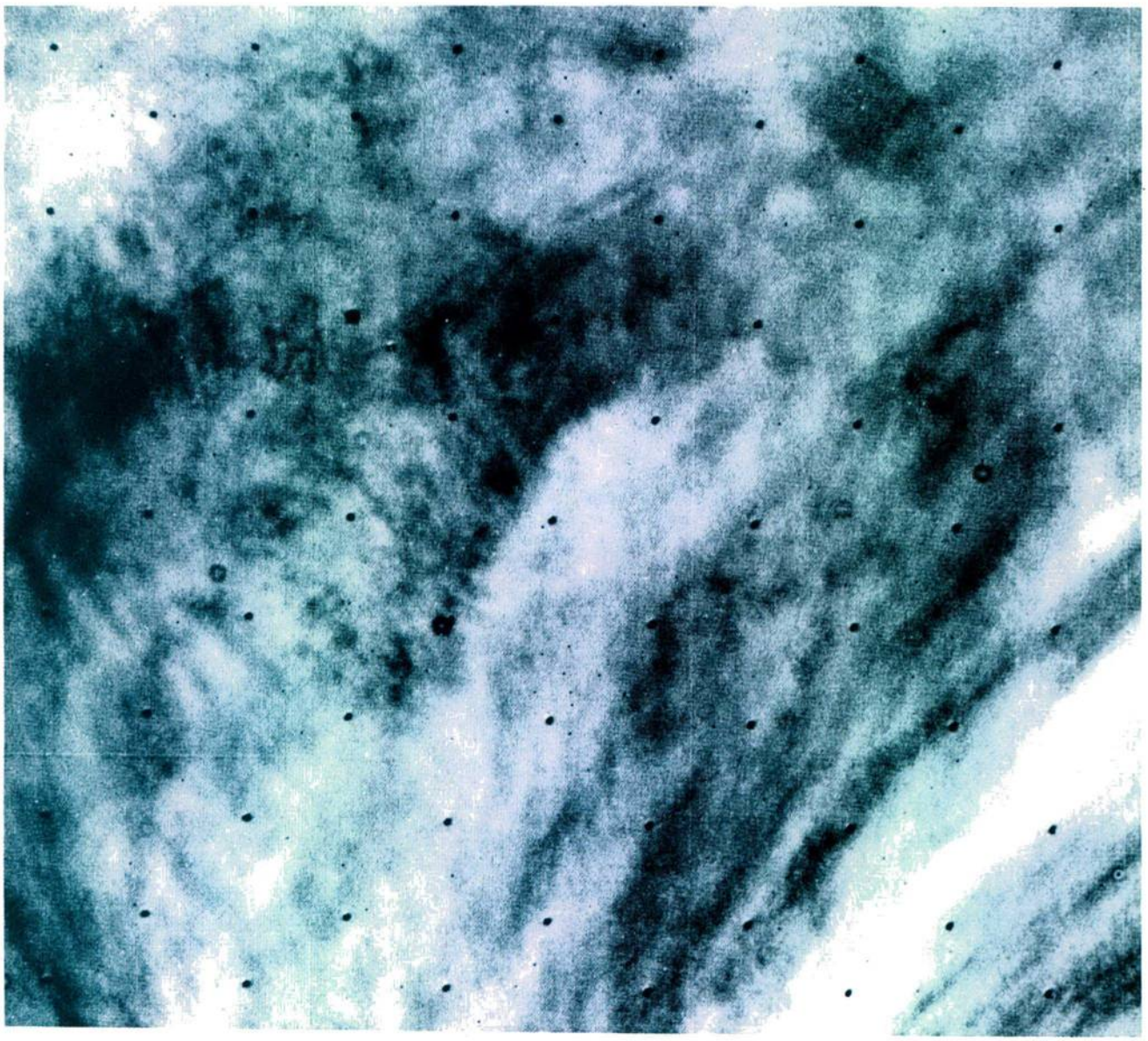




NASA Photograph

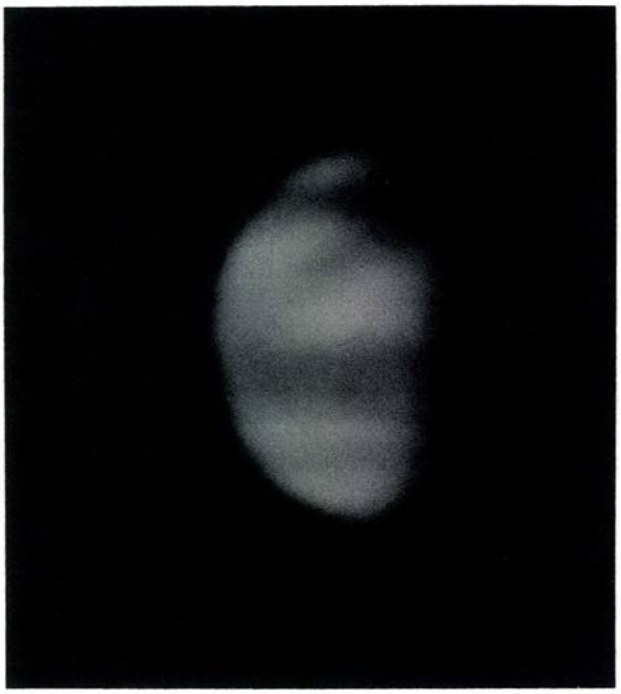
About 490,000 miles from Venus, on its way toward Mercury, Mariner 10 recorded this detailed ultraviolet photograph of a small section of Venus' cloud deck. The dark features toward the top are part of a dark belt in the Venus clouds over the equatorial region. Rising and descending air currents typical of convection on Earth are detected in this zone according to Mariner scientists. The dot pattern is part of the spacecraft's imaging system.

upper layer, it would be impossible to see the surface.

The temperature measured at the equator and the poles appears to be pretty much the same, around -10 degrees. But that's only the top layer of clouds. The temperature increases rapidly until at the surface it is +890 degrees — a situation that would allow pools of molten lead to exist if that element is on the surface of the planet. In addition to the forbidding temperatures, the pressure of the atmosphere is 90 times as great as it is on Earth. However this hasn't stopped successful exploration of the surface of Venus. Venera 8, the Soviet robot exploratory probe, landed on Venus in Dec. 1971 and reported that despite the high temperatures and density of the clouds, it is possible to determine the nature of the Venusian surface.

Venus is depicted as seen in invisible ultraviolet light by Mariner 10 from a distance of 450,000 miles.
NASA Photograph

Recently the Soviet Academy of Sciences released information on Venera 8's analysis of the Venus rocks. While on the surface, the spacecraft's gamma ray spectrometer detected characteristic gamma ray emissions of elements in the soil that suggest it is made up of rocks similar to earthly granite; that is, rocks melted from within the pla-



Lunar and Planetary Laboratory Photograph

Until the Mariner 10 mission, this was the most detailed photo of Venus taken from Earth. It shows, as do the Mariner photos, invisible ultraviolet features in the planet's clouds.

net, then hardened and subjected to further melting near the surface. All this implies that somewhat earthlike processes are going on at least in terms of the soil structure of Venus.

Venera 8 also told us that it will be possible to take photographs of the surface immediately surrounding a landing spacecraft since enough sunlight penetrates through the cloud cover to give a sort of twilight glow equivalent to about 1/10 the light that reaches Earth on an average day. In view of this, Boris Petrov of the Soviet Academy of Sciences reported that a new generation of Venera spacecraft is under development and will soon be launched toward the planet to continue direct investigations of the atmosphere and surface rocks. So perhaps we can hope for television pictures of Venus in the not-too-distant future.

As for the NASA Venus program, two Pioneer class spacecraft are in the works. One will be aimed on a collision course, but just before it plunges into the atmosphere it will drop four probes. One weighing about 60 pounds will descend by parachute and survive down to and on the surface of the planet; three smaller three pound atmospheric probes will make rapid descents and crash on the planet providing information on the way down.

The second Pioneer in the series will be an orbiter to continually monitor the cloud circulation and space environment around Venus. Both of these are late 1970s projects to pick up where Mariner 10 and the Venera probes left off.

Jupiter

The solar system's largest planet may ultimately prove to be the most important object in the solar system as far as man's understanding of the origin of his part of the universe is concerned. The great globe has more to offer than meets the eye. All we see is the top of an incredibly massive atmosphere — the arena of violent turbulence that was clearly revealed by the robot eye of Pioneer 10 when it hurtled by Jupiter in Dec. 1973.

Surging vortexes of gases and aerosols, belched from beneath smeared bands of billowing clouds, blend into a kaleidoscope of color in alternating dark and light hues giving Jupiter a stunning appearance when seen close up. The white and light yellows are high altitude clouds of ammonia crystals. Darker clouds of varying intensity are generally at a lower level and have a more complex consistency — possibly organic compounds. Hydrogen, oxygen, nitrogen and carbon in varying complex compositions make Jupiter's atmosphere a primordial "soup" much like Earth's atmosphere of billions of years ago.

One of the most exciting announcements to come out of the recent bonanza of planetary data concerns Jupiter's Great Red Spot — a colossal oval three times larger than the entire earth, and a complete mystery to astronomers since it was first recorded in 17th century telescopes.

Like a gigantic cyclopian eye, the spot seemed to pompously gaze from its position astride the striped face of the solar system's largest planet. Moving in a seemingly random fashion and changing color from bright orange to dull rust, the spot defied explanation. Now two independent discoveries have revealed much about this puzzling object.

Through a painstaking process, many of the Jupiter photos seen here have been turned from near meaningless blurs into these fantastic portraits of the cloud-whipped atmosphere of Jupiter. In particular the photos show the Red Spot deflecting nearby clouds and forcing them around it. Tom Gehrels of the University of Arizona, and one of the chief Pioneer scientists, has determined that the spot is four miles above the average cloud deck. He concludes that it is a massive storm that is "fed" by some source deep within the atmosphere that belches the spot material to great heights where it condenses to maintain the feature.

Independent confirmation of this concept was recently announced by a team of astronomers working with a new and extremely sensitive "heat" detector attached to the 200 inch Mt. Palomar telescope. Their measurements show the spot to be much cooler than the surrounding clouds, indicating a higher environment.

This towering storm hypothesis was predicted several years ago by Carl Sagan, Cornell University's brilliant planetary astronomer. Sagan and a Soviet scientist examined all possible models that might explain the spot and selected what has turned out to be the correct interpretation.

Now that we know what Jupiter's monstrous eye is, the next question is why. What drives the spot's material from deep within the atmosphere and how has it maintained itself for over three centuries? Somehow it's continually replenished from below with material that is different from the normal clouds. The spot's particles are now known to be more closely packed or differently shaped from the other clouds of Jupiter. Just what the mechanism is for the production of these particles and the almost volcanic-like emergence from deeper layers is, at present, unknown. But the basic mechanical nature of the cloud now seems to be definitely understood.

Over the rest of Jupiter, according to Gehrels, gases deep within the atmosphere are heated and rise in columns like earthly storm clouds. As the altitude increases, the gases condense to form aerosols or droplets and crystals giving the clouds their characteristic bright colors. Somehow hot spots deep within the planet's atmosphere are responsible for a lot of the turbulence that is visible at the cloud tops. Circulation cells are obvious, especially as white ovals, and these have been measured to be a few degrees warmer than their surroundings.

The average temperature of the clouds — taken by Earth based instruments — has been quoted generally as about 200 degrees below zero. Although Pioneer 10 found general agreement with these cloud top temperatures, for the first time it was learned that 125 miles down into the atmosphere (where the pressure is about 1/2 the surface pressure of the atmosphere on Earth), the temperature rises remarkably to +260 degrees.

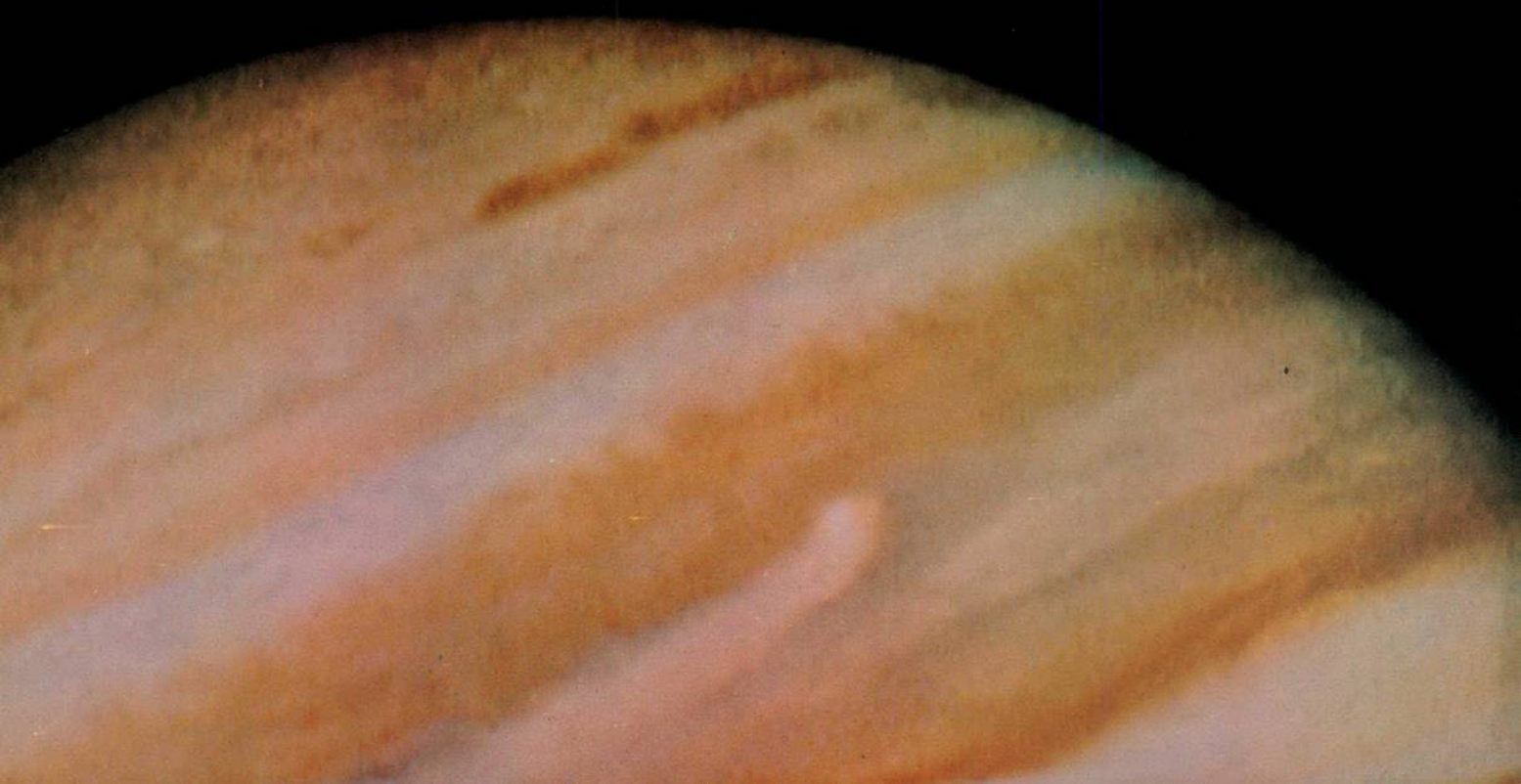
A 200 m.p.h. wind system whips the upper layer of the Venus cloud deck around the entire planet in four days. These three photos, taken at seven hour intervals, show how a 600 mile wide feature moves during that period. All cloud structures seen in these and other Venus photos are invisible to the human eye. The Jupiter and Mercury photos do, however, show what you would see if you could ride along on the spacecraft that took the pictures.

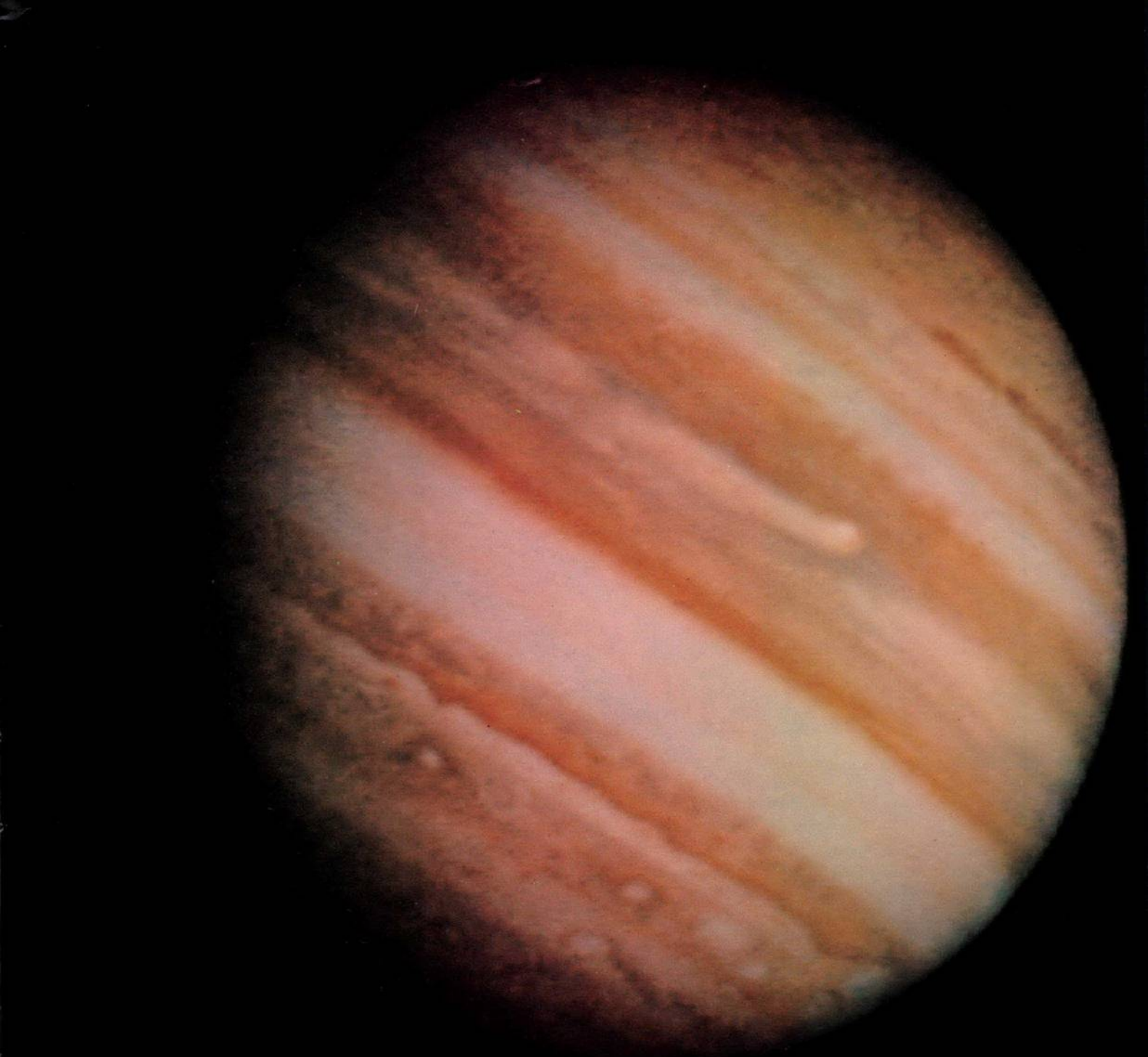
NASA Photographs

Farther down, at about 2-1/2 atmospheric pressures, the temperature was up to 800 degrees above zero according to the Pioneer measurements. Until this time, Earth based measurements had led us to believe that the temperatures at these levels were much lower. According to Arvydas J. Kliore of NASA's Jet Propulsion Laboratory, Jupiter has a "greater greenhouse effect than anyone expected". Apparently the incoming solar radiation is responsible for a lot of the upper atmospheric heating. The greenhouse concept was supported by Pioneer's detection of temperatures slightly higher on the day side of the planet, indicating that the partial source of the high temperatures is the sun's radiation that gets through the upper layers of the atmosphere and clouds but does not escape — thus producing the so-called greenhouse effect.

The higher temperatures mean that an exploratory probe of Jupiter (an atmospheric entry probe that would be something like a miniature version of the Apollo command ship that was used for the astronauts re-entry from lunar missions) would be possible as a means of examining the Jupiter atmosphere. A high temperature atmosphere is easier for entry probes because the gases

From only 800,000 miles away, Pioneer 10 viewed the northern portion of the clouds of Jupiter. This is a detailed view of the upper right part of the opposite page. The planet had completed almost exactly one rotation between the two photos. NASA Photograph





NASA Photograph

The most detailed view, showing Jupiter in its entirety, to come out of the Pioneer 10 mission reveals far more than can be seen in earthly telescopes. Here, from a distance of 1,120,000 miles, a bright nucleus at the head of a streaming 40,000 mile long cloud formation is suspected to be the site of "thermally driven rising cloud particles from deeper in the atmosphere" according to Tom Gehrels of the University of Arizona (where this picture was processed). The white ovals with dark rims in the southern hemisphere have been observed through telescopes on Earth, but never in detail as seen here. The largest of these cloud cells, or ovals, has a diameter about half that of Earth. These ovals appear to be rising cloud columns with the darker rings around the edges being regions of downward motion of the surrounding clouds.

A Very Special Time*

Guest Opinion by Carl Sagan

*A synopsis of remarks made at the San Francisco, Calif. meeting of the American Association for the Advancement of Science in Feb. 1974.

The naive idea that we knew a great deal about the solar system and that there would not be many surprises in store in future years was certainly one of the first casualties of the unmanned planetary program. It used to be that a planetary astronomer was entirely safe in the sense that he could make any speculation whatever about a planet or life thereon and could rarely be proved wrong.

One can find many such speculations, especially back at the turn of the century. For example, W.H. Pickering of Harvard hypothesized herds of foot long beetles migrating across the lunar crater Eratosthenes. This was thought to be a moderately respectable interpretation of lunar photometry in the 1900s. But now spacecraft hang like swords of Damocles over the heads of the theoreticians, and you can see on their faces a strange amalgam of hope and fear as spacecraft approach the planets.

Fortunately this has not led to a general abandonment of theoretical planetary astronomy but rather the opposite. I believe that theoreticians who are prepared to be proved wrong can play a very major role in helping to define planetary missions and to broaden the conceptual base of the missions. And I think that many of the possibilities that are considered far out, are so considered for reasons which involve essentially a lack of nerve rather than a lack of scientific support. One such speculation is the possibility of large organisms on Mars. That's one that somehow even the bravest planetary scientists somehow shirk from, perhaps because of the Lowellian tradition and Eratosthenian beetles. But on the basis of all the evidence that we have, I see no reason to exclude it and, indeed, there are interesting thermal balance and water conservation reasons why large organisms might do somewhat better than small organisms on Mars. I think likewise that there is a wide range of quite exotic possibilities for life in the outer solar system as well. But we don't have to wonder for very long. These ideas can be checked by future planetary missions.

Suppose we were interested in these very problems, but we were born one century earlier than we were. Who would we be? We'd be those guys who were concerned about what it was like on Mars in 1877 when the two moons and the canals were discovered. They didn't get very far; not because they were dumb; not because they didn't have the appropriate passions; but because the technologies were inadequate. Those fellows could ask the questions but they could never get the answers.

Now imagine that we were born one century later. It's the last third of the 21st century and all the answers are in. You will learn the answers before you've asked the questions. You'll go to school and in the second grade they'll tell you about the methane volcanoes of Titan.

Clearly the best time to be alive is when you start out wondering and end up knowing. There is only one generation in the whole history of mankind in that position. Us.

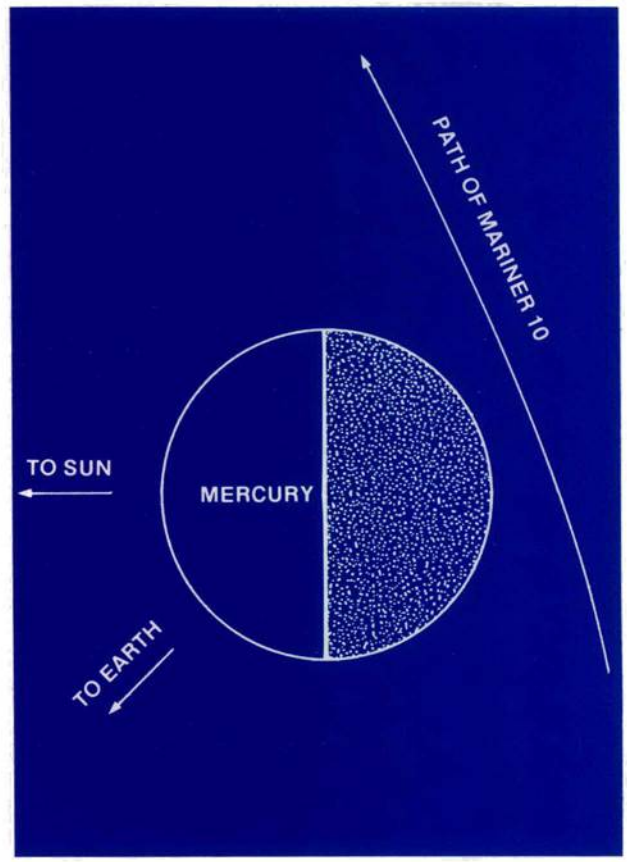
Professor Carl Sagan is director of the Laboratory for Planetary Studies at Cornell University. He is perhaps America's best known astronomer, due in part to his recent best selling book, **The Cosmic Connection** *(Doubleday, 1973), and to numerous appearances on NBC's* **The Tonight Show.**

are more diffuse and therefore less of a shock to a descending probe dropped from an orbiting spacecraft. So with this new information initial planning is underway for the design of a 1980s drop through the clouds of Jupiter. The probe is going to have an interesting time on the way down — it will meet 300 m.p.h. jet streams, savage turbulence and storm fronts.

Interest in Jupiter has always been high since it was realized that this planet may hold more secrets about the origin of the solar system than any other body. Contained within the great bulk of the giant planet are essentially all the products of the formation of the solar system. Because Jupiter emerged as such a large mass during its initial formation, the gravity that the protoplanet had (similar to its gravitational attraction today) was high enough to prevent the escape of virtually any gases. What was there in the beginning, is still there — unlike the four inner planets, which in addition to their own lesser gravities also had to contend with the energy of the sun. Both factors eliminated much of the primordial atmosphere of Earth and its companions in our part of the solar system.

Detailed measurements of the composition of Jupiter's so-called primordial atmosphere are finally available, thanks to Pioneer's experiment that measured the reflected ultraviolet light from the planet. Study of this data has revealed that 84 percent of Jupiter's atmosphere is hydrogen, 15 percent helium, and 1 percent methane and ammonia with trace amounts of acetylene, ethane and other less significant gases. These measurements imply that most of the bulk of Jupiter is hydrogen.

Let's descend into the atmosphere of this alien world in an indestructible submarine-type spacecraft. We would first encounter high altitude ammonia clouds that would probably look like the flimsy cirrus clouds of our skies. Below, at warmer levels, would be layers of clouds made of ammonium hydroxide (water and ammonia) droplets. Here, much of the organic chemistry that produces cloud colors takes place. After descending through that layer we would encounter vast sections where the atmosphere is essentially clear. If enough sunlight filters down to this level we could see for many miles, and we might get the feeling that we're plunging into an abyss — a bottomless pit that gets darker and darker as we descend. The pressure of the atmosphere increases to 10 and then 100 times the surface atmospheric pressure on Earth. But it wouldn't stop there; it would keep increasing to 1,000 and then 10,000 times until pressure equivalent to that at the bottom of the deepest ocean trenches on Earth would be crushing around our capsule.

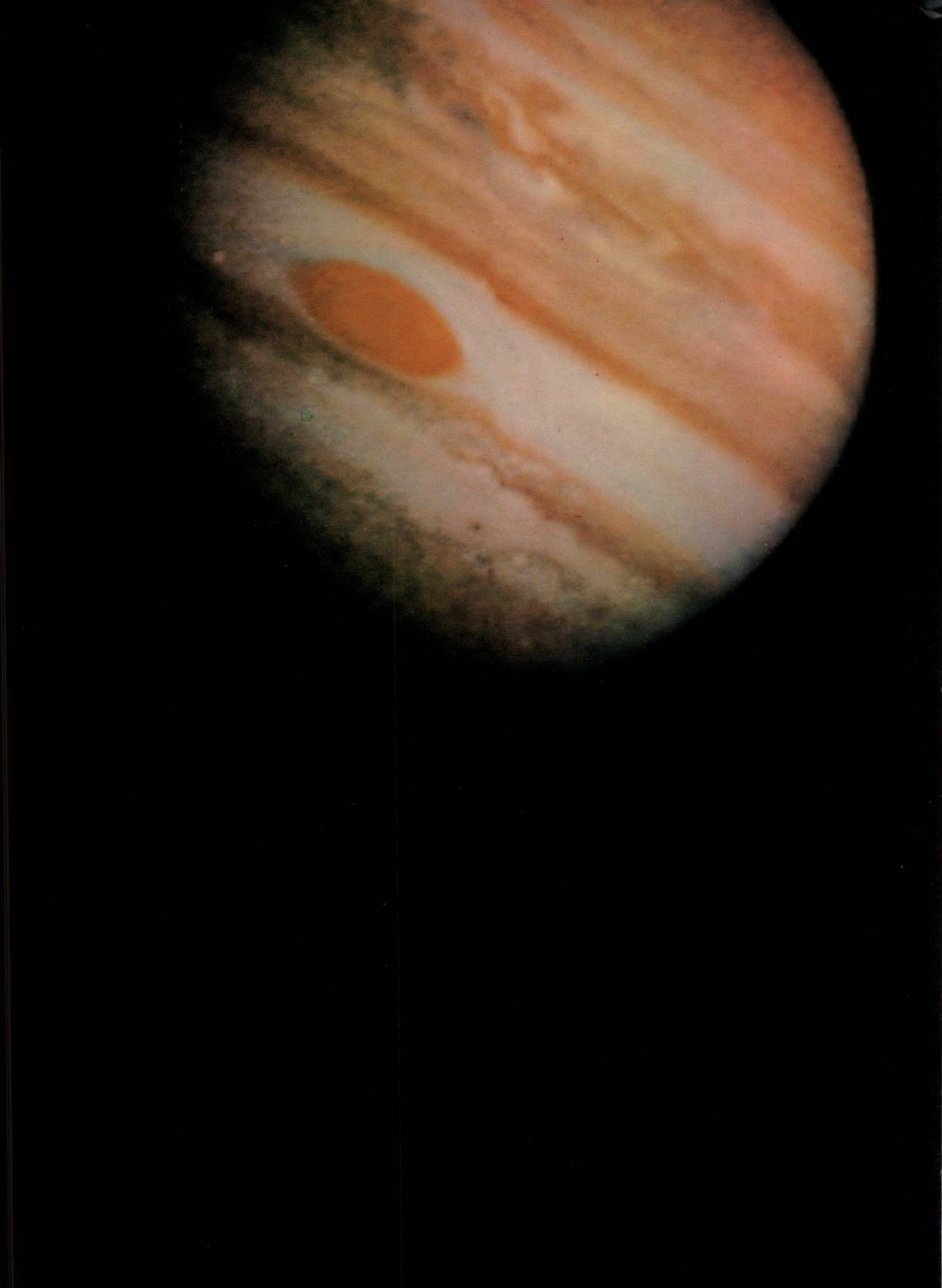


Mariner 10 flew past the night side of Mercury as indicated in this diagram depicting the view from above. Closest approach was only 431 miles. More than 1,000 television pictures were taken on both the inbound and outbound legs of the flyby. When Mariner 10 comes around to Mercury again on Sept. 21, it will (if it is still functioning) likely be targeted to sweep under the planet's south pole.

But we'll continue our journey undaunted down to the "surface" of Jupiter where the atmosphere turns into an almost slushy substance. As the temperature and pressure increase we would eventually be stopped by a core of solid hydrogen under enormous pressure. (Actually the hydrogen is crushed into "metallic" hydrogen, denser than lead.)

Does this primitive planet ever change? Has it changed at all since the origin of the solar system? The betting now is that Jupiter has remained essentially the way we see it today since its formation. Nothing has affected it. The collision of a comet or an asteroid would be merely a pinprick to giant Jupiter. Whereas on the moon and Earth, vast scars have been left by such impacts, Jupiter could toss off an impacting body many hundreds of miles in diameter without the slightest effect. Maybe the only visible scar of such an impact would be a feature something like the Red Spot.

So external forces don't seem to be involved in changing Jupiter. The layering and structure



NASA Photograph

A wealth of Jupiter's cloud detail was captured by Pioneer 10 in this photo taken only 616,000 miles from the giant planet. Only the north quarter of the planet is seen in the photo which shows details of the upper part of the picture opposite. The most notable feature is the whirl of cloud motion seen on the extreme right. Its edges and boundaries are remarkably sharp. Apparently there is, on Jupiter, an appreciable amount of north-south motion in addition to the predominant east-west belts and zones seen in Earth based photographs. These cloud features are the size of continents on Earth.

of its atmosphere would remain basically static since nothing can escape, nothing is going anywhere, and nothing is evolving. Jupiter is as it was 4-1/2 billion years ago when it and Earth formed.

Some recent studies have indicated that the Jupiter environment, alien as it has sounded, can be the abode of life. For many years Carl Sagan has been making statements such as, "Jupiter looks like a terrific place for life." On the other hand you can read in most older astronomy textbooks that Jupiter is far too cold for life. Of course they were unimaginatively referring to the -200 degree readings taken at the top of the cloud levels.

Here is some support for the "life on Jupiter" hypothesis: Bacteria survive in certain springs in California that are 10 times more alkaline than was thought possible for sustaining any form of life. (The alkalinity of Jupiter's atmosphere, especially ammonium hydroxide, was once thought to be lethal to all forms of life.) Some bacteria collected near Mt. Shasta have been surviving in the presence of high concentrations of ammonia. Other bacteria survive temperatures over the boiling point of water. And others don't require oxygen for their existence. So the simplest forms of life here on Earth are existing under abnormal conditions on our planet which are normal conditions for Jupiter — which makes nonsense of the statement that life is impossible on Jupiter. What those statements really mean is that Jupiter is so different from Earth that it's hard to imagine life on that planet — but that's no reason for assuming that it isn't there.

The giant 25,000 mile long Great Red Spot is seen in greater detail than ever before in this Pioneer 10 photo taken from a distance of 1,305,000 miles. Flow patterns around the spot are evident in the cream colored south tropical zone surrounding the spot. Below and almost touching the spot, the brown south temperate belt is also disturbed by the spot. Data for the upper part of the photo requires further processing; however, a close-up of this area is seen on the opposite page. NASA Photograph

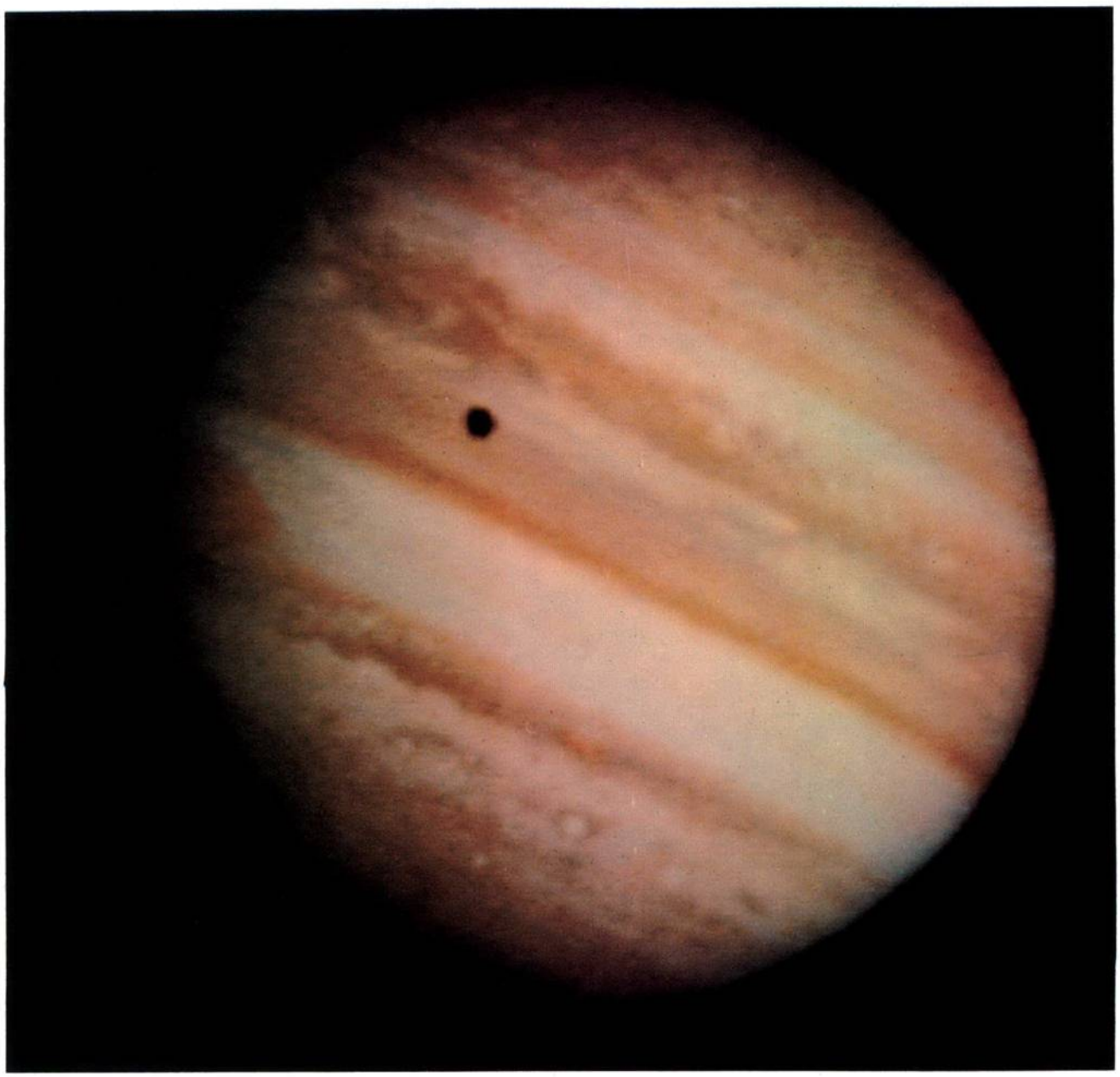
As mentioned in last month's feature article, "The Forbidden Moons", manned exploration in the immediate environment of Jupiter seems to be highly unlikely in the foreseeable future. A magnetic field that molds deadly radiation belts has created zones that Pioneer 10 found to contain a thousand times more high energy electrons than were predicted prior to the mission. Radiation was definitely detected at greater than the Earth-sun distance from Jupiter. At 30 million miles from Jupiter the magnetic field is essentially frozen into the planet's spinning. Rather curiously, on the way out Pioneer found that the magnetic field rotates with the planet out to about 80 million miles. The magnetic field of Jupiter and the associated radiation are in many places unpredictable in intensity, enormously complex in structure, and often deadly dangerous.

The moons of Jupiter have continued to be objects of interest for earthbound astronomers as well as scientists on the Pioneer team. Audouin Dollfus of the Paris Observatory reported at a recent lunar science conference in Houston on the optical reflectiveness and polarization studies that he has been making of the four big moons of Jupiter. He reported convincing evidence that Europa is virtually entirely frost covered — an observation that has been generally confirmed by other observers (although Dollfus' studies are probably more exhaustive than those of anyone else). Using the same techniques he noted that Ganymede has frost patches — also not an unexpected observation. Ganymede is the largest of Jupiter's moons and the only satellite in the solar system that is larger than a planet (Mercury).

But Dollfus' report on the surface of Callisto presents a new enigma. Here are the facts: As Callisto orbits around Jupiter, it — like every other major satellite in the solar system — faces

Artwork ©by Ron Miller

If you could explore the clouds of Jupiter, a scene like this might be encountered near the top of the Jovian cloud deck. A giant convection cell produces a towering cloud cell (right) similar to the ones seen from afar by Pioneer 10. The lightning below the clouds might pose a problem for an exploratory probe. Two of Jupiter's large moons are ringed by halos caused by reflection from high altitude ice crystals in the Jupiter atmosphere.



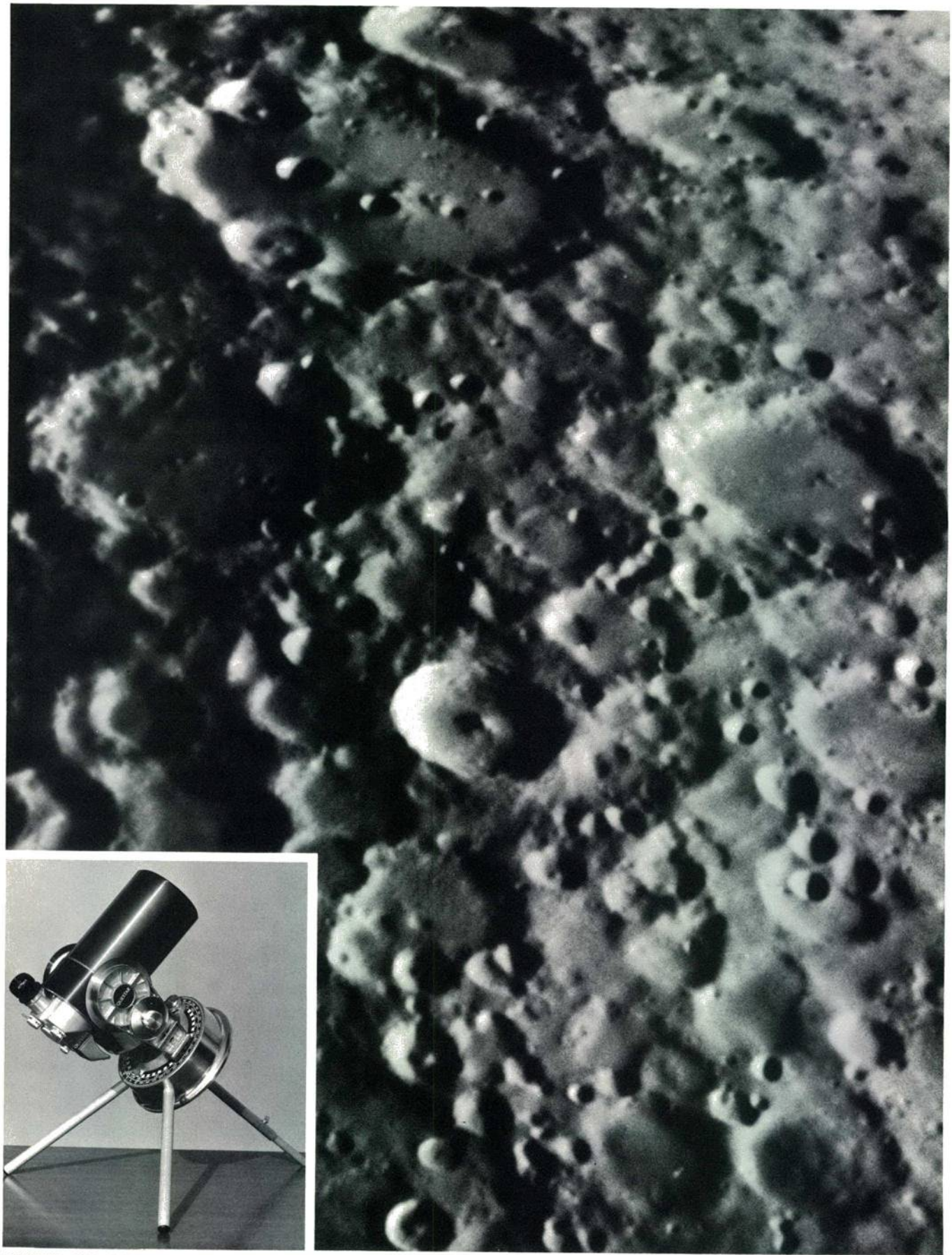
NASA Photograph

The shadow of Jupiter's inner major moon, Io, is clearly seen on the equatorial region of the planet. The Great Red Spot — now known to be a towering cloud formation — is just coming into view as the planet rotates from left to right. Jupiter's rapid 10 hour rotation undoubtedly causes some of the turbulence seen in the belts and zones. Pioneer 10 was 1,615,000 miles from the giant planet when this photo was taken on Dec. 2, 1973.

its parent planet; that is, one side of Callisto constantly faces Jupiter and the other side is always turned away. In this situation, half of the planet faces toward the direction of revolution and half faces away from the direction of orbital motion. In other words, on half of the planet you look at where you're going and on the other half you look at where you came from.

Now this distinction is important because Dollfus found that the leading hemisphere has a structure and surface composition essentially like the moon. But the trailing hemisphere is bare rock, having no moonlike dust on its surface. The observation cries out for further study and if proven true provides a real paradox for planetary scientists. One suggestion that Dollfus made was that the trailing side may have been covered with ice that only recently was melted. But why this side was favored remains obscure.

Due to the length and significance of the feature article this month, our regular departments **Stellar Frontiers** *and* **Photography in Astronomy** *have been omitted. They will return next month.*



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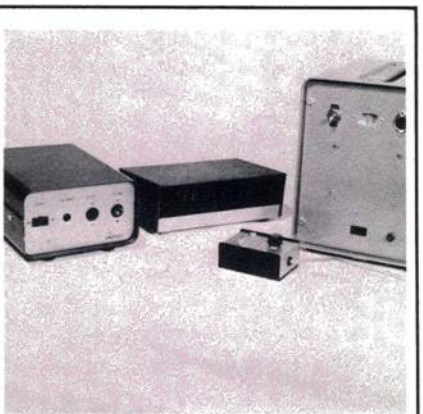

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ANNOUNCEMENT — The 1974 Nat'l. Convention of the Astronomical League will be held at Michigan State University in East Lansing on Aug. 14-18. Amateurs interested in submitting papers should contact program chairman Louis Faix, 6088 Robin Hill Rd., Washington, MI 48094. Discussions on all facets of observing, astrophotography, equipment construction and operation are invited. Oral presentations should be about 20 minutes long. Submit abstracts ASAP; drafts required by June 15.

ANNOUNCEMENT — Joint annual meeting of the Royal Astronomical Society of Canada and the American Association of Variable Star Observers will be held at the University of Manitoba in Winnipeg on June 28-July 1. For further information write Richard Bochonko, Astronomy Dept., University College, University of Manitoba, Winnipeg, Canada R3T 2M8.

ANNOUNCEMENT — 3rd annual conference of the Astronomical Association of Northern California will be held on June 29-30 at Lawrence Hall of Science in Berkeley. Program will include speakers; telescope and astrophotography displays and competition; scientific experiments, demonstrations, etc. To preregister, write AANC Conference, 4312 Agena Circle, Union City, CA 94587.

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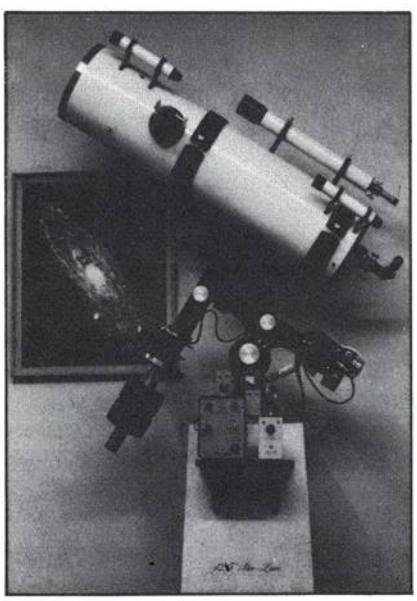

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JUNE

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

Map Centered on 43° North Latitude

MAGNITUDES

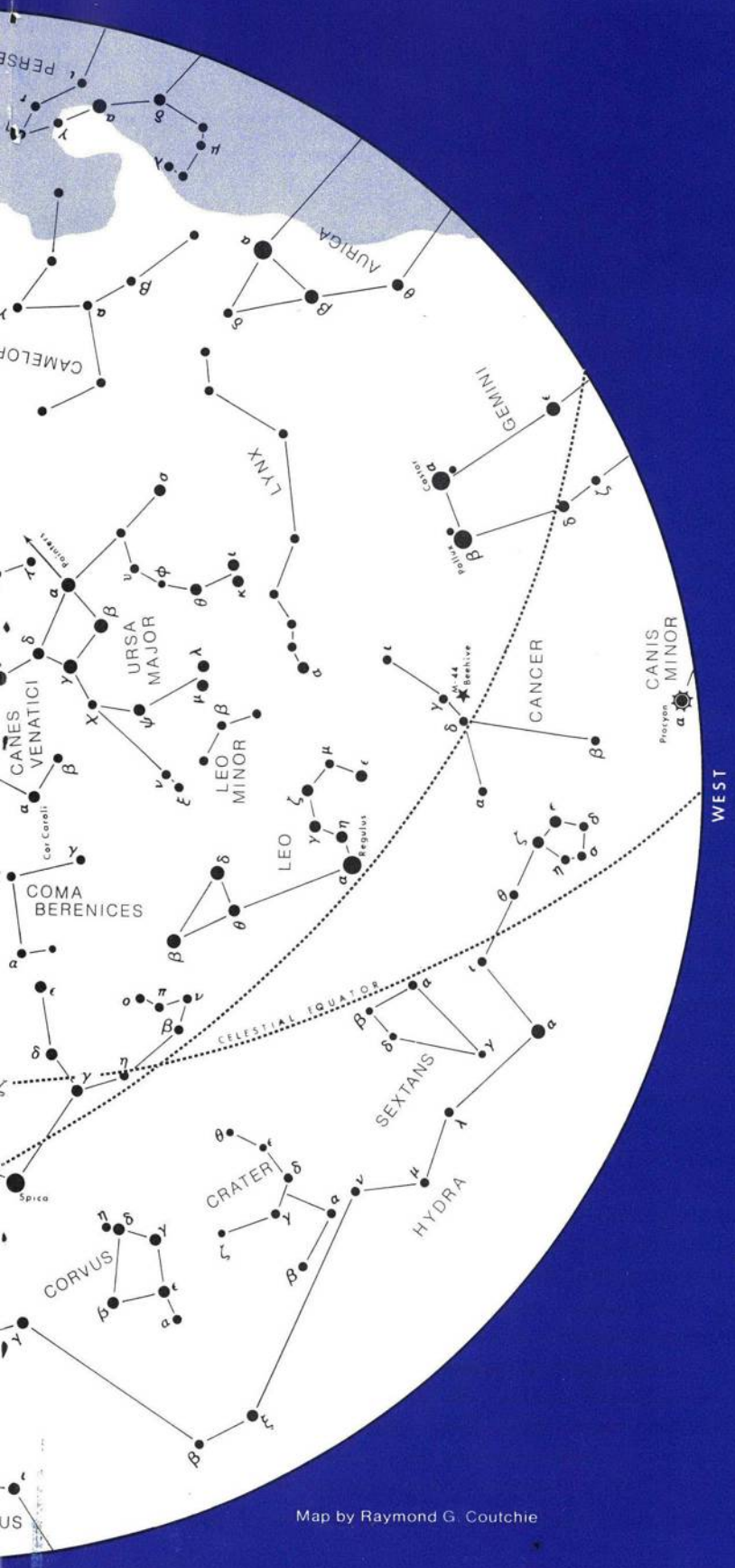
- Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars

Star Dome approximates the sky as it appears at 10 p.m. Local Daylight Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

STAR DOME



Map by Raymond G. Coutchie

How often in past summers have you looked at the star studded velvet blackness on a warm, clear, moonless evening? Have you wondered how many millions of stars are spread before you as you lean back and examine the celestial vault above? Possibly it's better if these idle musings remain simply that; but then again curiosity should be satisfied by some answers (which in a healthy situation always leads to more questions anyway). So here are some statistics for the casual summer sky watcher.

Under the most dazzling of conditions, where stars seem to fill the sky from zenith to horizon, you probably cannot see more than 4,000 stars — even if you have excellent eyesight. And most of those stars will be on the threshold of your vision. They seem to be just there — sort of a haze between the brighter stars. If you glance away you see them; but when you look directly at them, they disappear. This is not an inaccurate impression because more than half of the stars that you can see are the ones that are near the threshold of human sight. But the "averted vision" property of the human eye is real. The eye can detect fainter images away from the direct line of vision. That is, if you just look away from something that you are trying to see, it will pop into view; but when you look right at it, you can't see it. Let's try an example of this kind of viewing.

If you can find the constellation Hercules, as marked on our Star Dome map this month, you will see indicated the globular cluster marked M-13. This is one of those threshold vision objects — something that you can only see with the unaided eye under excellent sky conditions where there's not much haze, the moon is out of the sky and you're well removed from urban lights.

So if you're up to the test, and you think you've found the location of M-13, look off to the side and you should see it more clearly as a slight hazy patch. Then look back and see if you can see it while looking directly at it. Most people can't. If you're not quite sure, you can help yourself by bringing your binoculars into play.

Binoculars are the astronomy enthusiast's

best "friend" after his telescope. But it's surprising how many good binoculars spend summer evenings in their imitation leather cases. Binoculars will bring this little hazy patch from the limit of visibility to obvious conspicuousness. It won't appear like a star. It will perhaps look like Comets Kohoutek or Bradfield without their tails. In reality this little hazy patch is about a million stars grouped together in a spherical swarm like those clouds of little insects that annoyingly hover on calm early summer evenings.

If you try to locate M-13 and cannot, it's probably because you're having difficulty locating Hercules himself — a rather dim constellation and one that is difficult to find if you're feeling a little shaky about constellation identification. So let's back up a step. We will go back to the "starlost's" friend, the Big Dipper (part of Ursa Major).

We mentioned last month that the Big Dipper is a useful pointing device to aid in finding basic star groups. The curve of the Big Dipper's handle can be extended in an arc down to the bright yellowish star Arcturus in the constellation Bootes. That is step one. Step two is to look toward the northeast for a star about the same brightness as Arcturus but bluish in color and far brighter than any nearby stars. This is Vega, brightest star in the small constellation Lyra, the Harp. With these two major identification stars definitely located, you can now zero in on Hercules.

Between Arcturus and Vega, and on a line connecting these stars, is Hercules and a smaller but easily identified group, Corona Borealis. If the sky is hazy or lit up by lunar or man made light, try tracing out the major star formations of Bootes, Corona Borealis, Hercules and Lyra with the help of binoculars.

Now you can try again for M-13. Finding an obscure object is really not hard at all. Once you locate the Big Dipper, it all falls into place.

Hercules, muscular star of Greek mythology, is generally a dim constellation that (as usual) does not resemble the figure of a man. Some sky observers say the star group looks like a butterfly. Does it look like any familiar object to you? We all know the "real" Hercules, thanks to those dubbed Italian movies where the hero fought off dragons, legions of armored soldiers, and the amorous advances of leading ladies — all with equal ease.

Speaking of dragons, Hercules has his foot planted on the head of Draco, the Dragon. (Gamma and Beta in Draco are the eyes of the beast.) Presumably Draco was the guardian of the tree of golden apples, the object of one of Hercules' famous "twelve labors". It's all part of an unbelievable story that we will save for next month.

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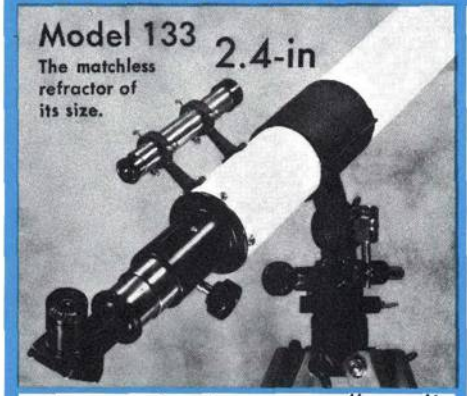

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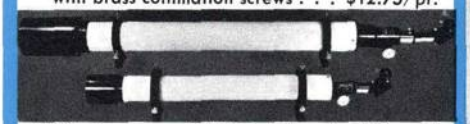

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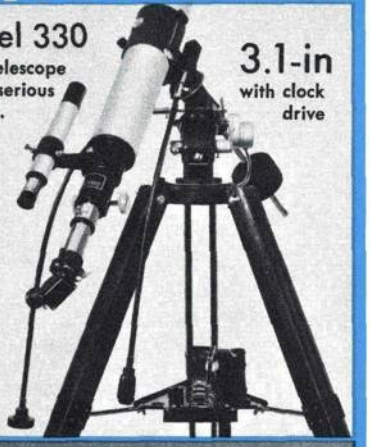

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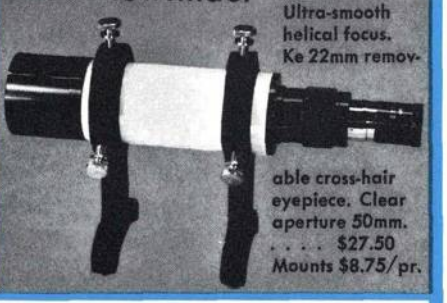

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THE ACTION IS WHERE WE AIN'T

Photograph by Patrick Michaud

On April 13, 1974, Comet Bradfield passed within five degrees of the "double cluster" in Perseus. The comet was about sixth magnitude at this time — about the same overall brightness of one of the two star clusters.

The most spectacular of all sky phenomena — a total eclipse of the sun — takes place this month on the other side of the world. We also miss a partial eclipse of the moon because North America is turned in the other direction. This month we lose Saturn from the evening sky and Mars becomes very inconspicuous. Only a chance to observe Mercury brightens an otherwise bleak picture on the planet-sun-moon scene.

Mercury

The inner planet makes a rare and very favorable appearance early this month. Some details were given in this department in the May issue, and this month's Gazer's Gazette is devoted entirely to Mercury.

Venus

Still conspicuous in the early morning sky, the cloud covered planet is a rather uninteresting telescopic object. This is due to Venus' location on the far side of its orbit, giving us an almost "full" view of its brilliant reflective clouds. The crescent phases earlier this year were larger and prettier than this month's view (see diagram, page 55). On the 1st, Venus is 14.9 seconds of arc in diameter and appears 74 percent illuminated. By the 30th the diameter is down to 12.7 seconds with an 82 percent illuminated disk. Distance to Venus increases from 105 to 123 million miles during June.

Mars

Nearly as far from Earth as it can get, the red planet is easy to overlook. It is now 50 times

fainter than it was in Oct. 1973. At that time Mars was 40 million miles away, but that distance increases to 206 million miles by June 1 and will be 223 million miles by the 30th. The second magnitude planet (now in Cancer) is of no interest in the telescope; its apparent diameter decreases from 4.3 to 3.9 seconds of arc during the month.

Jupiter

If the magnificent photographs of the giant planet displayed in the feature article this month make you itchy to observe Jupiter for yourself, you can find it low in the east around midnight or shortly thereafter. You can't mistake Jupiter; it shines brighter than any star or planet except Venus (which won't be in the sky at that time anyway). Jupiter rises earlier each night throughout June and the following months.

The positions of the four large moons of Jupiter are given in the table. Sometimes the moons cast their inky shadows on Jupiter (see satellite shadows table). The shadows are visible in a 2.4 inch refractor according to some of our readers.

Earth and Jupiter are approaching minimum distance from each other (370 million miles on Sept. 5), so for the next few months viewing will improve as the planet grows in apparent size. During this month its apparent equatorial diameter increases from 39.5 to 43.5 seconds of arc as the distance between Earth and Jupiter is reduced from 464 to 422 million miles.

Saturn

For the first few days of the month Saturn will provide an interesting naked eye and telescopic comparison to Mercury (see Gazer's Gazette). But after that the motions of Earth, Saturn and the sun cause the sun to appear to move between us and the ringed planet, thus terminating this season's Saturn viewing.

The Moon

Always there but often forgotten is the super showpiece of the sky. Except when nearly full, the moon provides countless hours of peaceful telescopic enjoyment.

Occasionally the moon can cause a relatively rare and beautiful atmospheric phenomenon that sometimes catches even the experienced sky observer by surprise. Most spectacular is the lunar halo.

The circumstances needed for a lunar halo are an evening with a full moon and a temperature around 35 or 40 degrees. All that has to be added is a layer of high altitude ice crystals like those in cirro-stratus clouds. It's the regularity of shape of the ice crystals that causes the halo. They act like little prisms refracting moonlight at a 22 degree angle to form a ring around the moon with a 22 degree radius.

The halo was especially bright on the evening of March 9, 1974 when Don Dean caught a 15 second exposure (shown on page 49) from Marshalltown, Iowa. Usually the halo is simply white, but Dean's photo shows a hint of rainbow tints that are only rarely seen.

According to beliefs popular earlier this century, a halo around the moon or sun was a forerunner of rain. Since both types are caused by light cirro-stratus clouds and since rain frequently follows such clouds, there was often truth in the prediction.

Lunar Eclipse

On the night of June 4, Asia, Australia, Africa and Europe will be treated to a partial lunar ec-

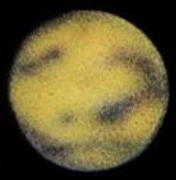
SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EDT)	Transit ends (EDT)
June 1	3	3:22 a.m.	6:53 a.m.
4	1	4:04 a.m.	6:19 a.m.
6	2	3:11 a.m.	6:04 a.m.
13	1	12:26 a.m.	2:41 a.m.
20	1	2:19 a.m.	4:34 a.m.
27	1	4:13 a.m.	6:28 a.m.
July 1	2	12:19 a.m.	3:11 a.m.

1 Io
2 Europa
3 Ganymede
4 Callisto

Ⓒ Ceres

June	1	15
R.A.	23h06m	23h16m
Dec.	-16° 29'	-16° 30'
Mag.	8.4	8.4



Ⓐ Mercury

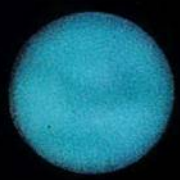
June	1
R.A.	6h 20m
Dec.	+ 25° 14'
Dia.	7.7"
Mag.	+ 0.3

Ⓑ Mercury

June	15
R.A.	6h 58m
Dec.	+ 21° 56'
Dia.	10.1"
Mag.	+ 1.5

Ⓜ Mars

June	1	15
R.A.	7h 52m	8h 28m
Dec.	+ 22° 22'	+ 20° 29'
Dia.	4.3"	4.1"
Mag.	+ 1.9	+ 2.0

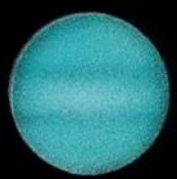


SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

June	1	15
R.A.	6h20m	6h28m
Dec.	+ 22° 44'	+ 22° 41'
Dia.	too near sun	
Mag.	too near sun	

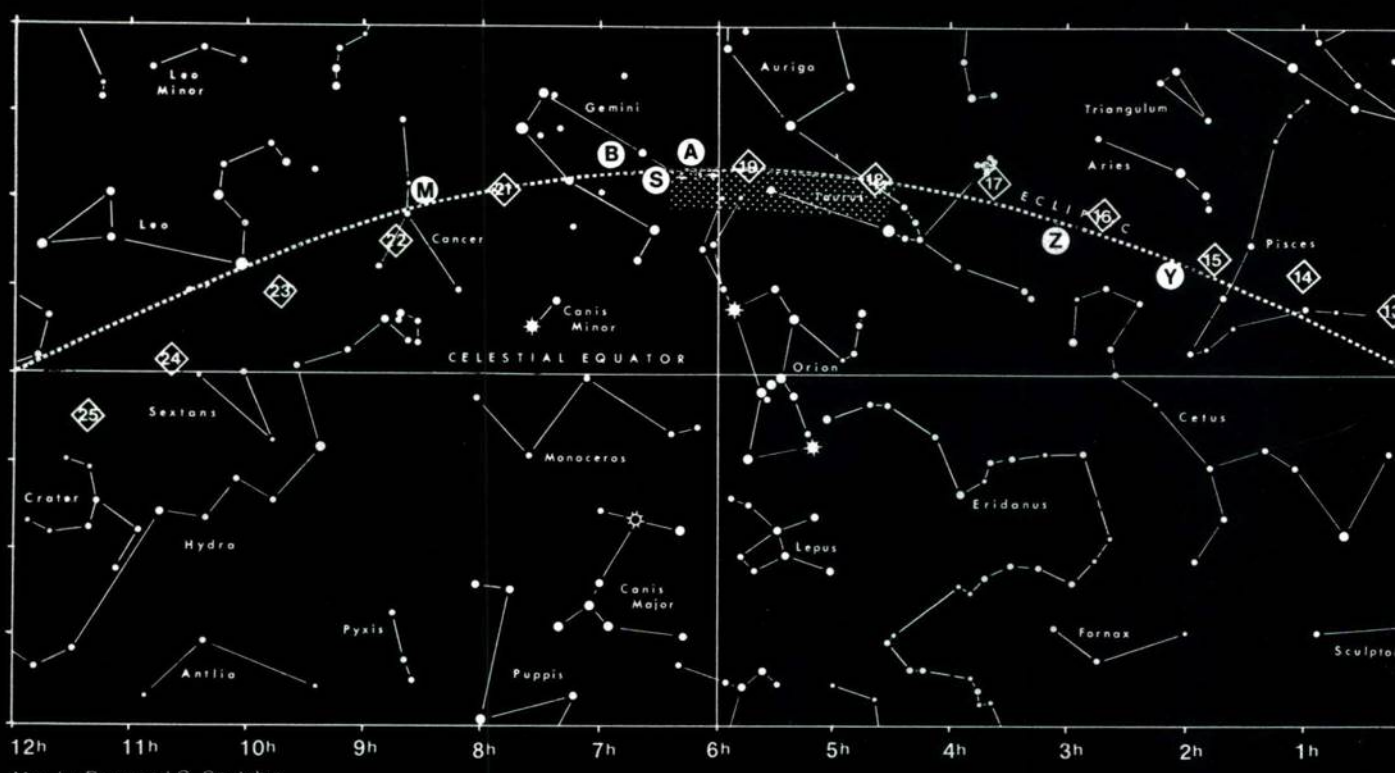


Ⓤ Uranus

June	15
R.A.	13h 29m
Dec.	-8° 41'
Dia.	3.9"
Mag.	5.8

Ⓝ Neptune

June	15
R.A.	16h 25m
Dec.	-20° 00'
Dia.	2.5"
Mag.	7.7

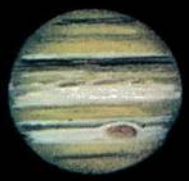


Map by Raymond G. Coutchie

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and DEC. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. MAG. = magnitude, a

Ⓥ Vesta

June	1	15
R.A.	12h31m	12h38m
Dec.	+7°00'	+5°04'
Mag.	7.2	7.2



Ⓙ Jupiter

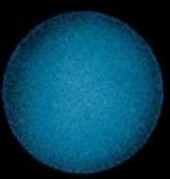
June	1	15
R.A.	23h10m	12h14m
Dec.	-6°33'	-6°07'
Dia.	39.5"	41.2"
Mag.	-2.0	-2.1

Ⓨ Venus

June	1
R.A.	2h02m
Dec.	+10°11'
Dia.	14.9"
Mag.	-3.5

Ⓩ Venus

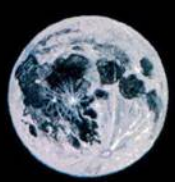
June	15
R.A.	3h05m
Dec.	+15°21'
Dia.	13.8"
Mag.	-3.4



Ⓟ Pluto

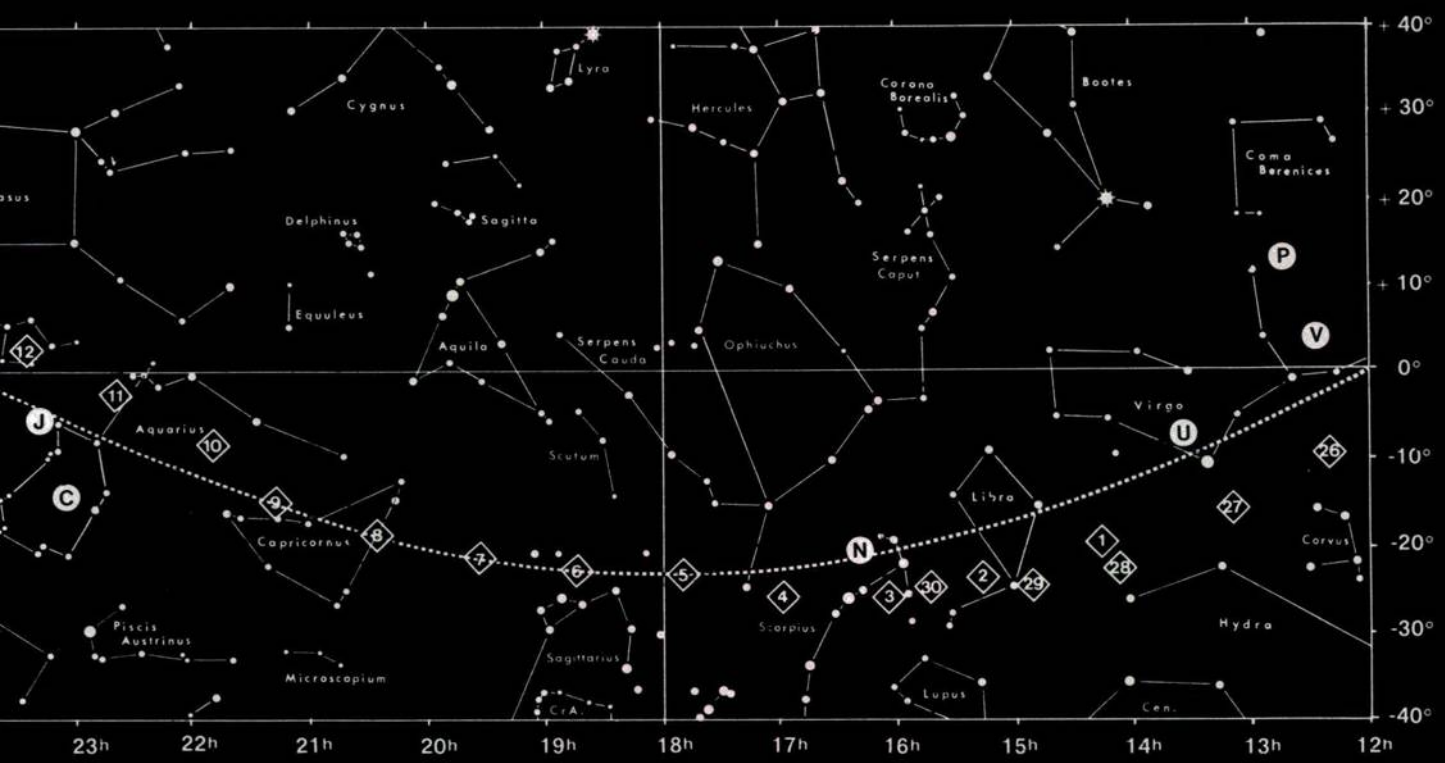
June	15
R.A.	12h40m
Dec.	+13°54'
Mag.	14

First Quarter
June 26



Full Moon
June 4

Last Quarter
June 12



Artwork by Victor Costanzo

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) DIA. = the planet's apparent diameter in seconds of arc. The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th.

Photographs by Mark McConnell

Mars made a trip through Taurus earlier this year, passing between the Pleiades (right in both photos) and the Hyades (the V-shaped cluster to left). Mars was about the same brightness as Aldebaran, the bright star at the top of the left side of the Hyades "V". Top photo is a 30 second unguided exposure on High Speed Ektachrome with a 58mm f/2 lens on Feb. 26. Bottom is a 20 second exposure on March 12.

lipse when 83 percent of the moon will be dipped in Earth's shadow. But North Americans will see none of it.

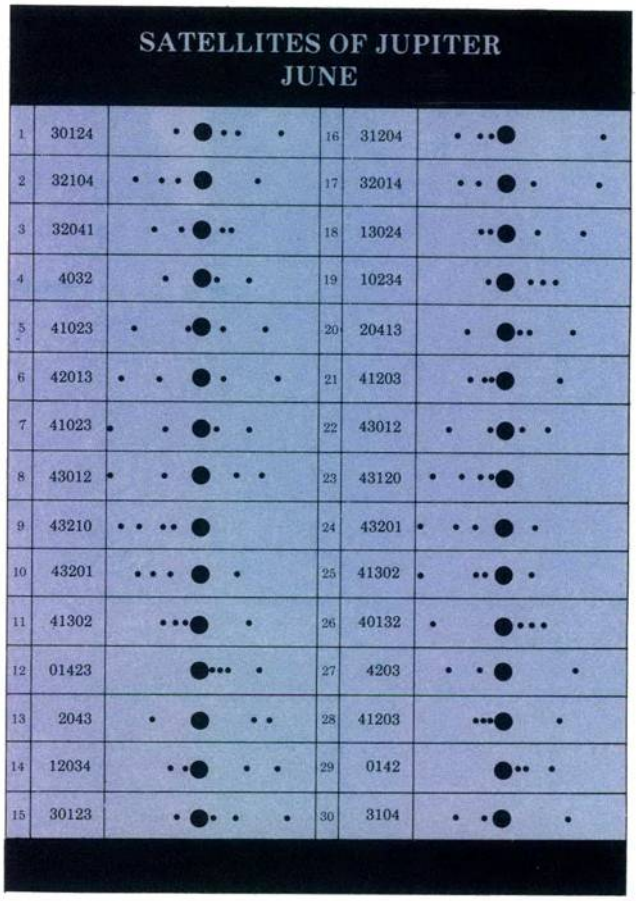
Meteors

On a clear moonless night the sharp eyed observer can expect to see five meteors per hour during the first few hours of the evening. After midnight the rate goes up slightly to eight or nine per hour. When more meteors are seen, the phenomenon is called a meteor shower.

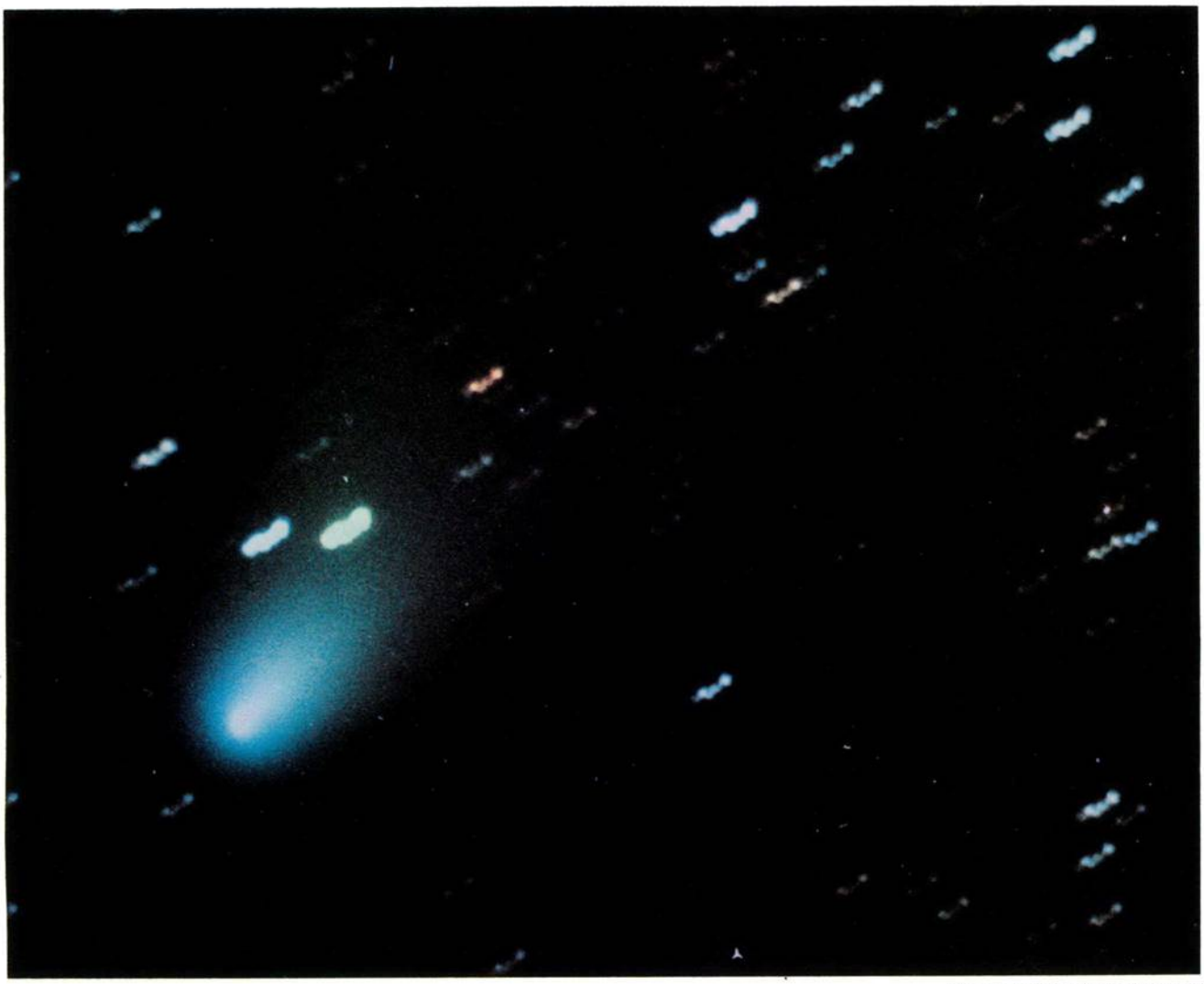
Two weak showers occur near the time of the new moon this month. These are the June Lyrids (June 15) and the Ophiuchids (June 20) named after the constellations from which the meteors seem to originate. Neither group is worth losing sleep over; but if you see a few more meteors than usual during midmonth, these sparse showers are likely the reason.

Total Solar Eclipse

A total eclipse of the sun — nature's super spectacular — is due on June 20. But don't get excited. Unless you plan to be in Australia, you won't see it.



The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about midnight (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto, and 0 = Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.



Photograph by Orien A. Ernest

Comet Bradfield on April 13, 1974 had a short stubby tail and bright coma. A 16 inch f/6 Newtonian reflector was used for this 15 minute exposure on cooled emulsion High Speed Ektachrome. The skewed star trails are due to the extreme difficulty encountered when compensating for the comet's motion across the sky.

A "good" eclipse used to be one whose path of totality crossed land in an accessible part of the world. In recent years though, several resourceful entrepreneurs have arranged cruises on luxurious ocean liners that park where the eclipse occurs. The trips include the usual goodies with stops at exotic ports, and have met with great success. Since most of the world is ocean, an eclipse path is more likely to be favorably placed over water.

So it is with the Australian eclipse. The path just nicks the southwest corner of the continent; the rest is over the Indian Ocean.

During totality the pearly atmosphere of the sun (called the corona) seems to magically emerge from nowhere once the brilliant face of our star is obscured by the moon. Like a ghostly halo it hangs in a blackened sky. In moments the eclipse is over and daylight returns, abruptly ending the midday night.

Over a vast area around the limited zone of totality a partial eclipse is seen. But the partial event in no way compares to the "real thing". In fact during past partial eclipses, the entire event has been overlooked by millions of people whose attention was not drawn to the partially obscured sun. But all this is idle musing since not even the partial phases of the eclipse will be visible outside Australia and southern Asia.

Looking ahead, a partial eclipse will be seen over the eastern half of North America on Dec. 13, 1974. The path of totality will miss Earth completely this time. There will be two similar partial eclipses in 1975, neither one visible from North America. On Oct. 23, 1976, Australia and the Indian Ocean will be treated to another total eclipse like this year's.

Lick Observatory Photograph

Comet Bradfield shows a brilliant coma and a faint veil-like tail in this 10 minute exposure. A 10 inch photographic refractor was used for this yellow light photo taken on March 23, 1974.

The Comet Bradfield Incident

On Feb. 12, 1974, William A. Bradfield, an Australian amateur astronomer, discovered a comet that turned out to be a moderately bright object during the last two weeks of March (see photos pages 41–2). Unfortunately the time between the comet's discovery and its period of maximum brightness was too brief for us to make worthwhile mention of it. ASTRONOMY is prepared for the printer about a month before you receive it. This lag is not a significant barrier except for information on rapidly changing phenomena such as comets and novae.

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ASTRO-NEWS

Latest News From the World of Astronomy

Part of Quasar Puzzle Solved

Are quasars actually incredibly powerful sources of radiation near the "edge" of the universe, or are they relatively nearby and less energetic? For 10 years this question has remained unanswered because of two contradicting pieces of evidence.

By their redshift (displacements of telltale lines in the analyzed light of quasars), they seem to be billions of light-years away. But if quasars are that far away they are emitting up to 100 times the radiation of an entire galaxy — far too much to be explained by today's physics.

This paradox has led some astronomers to suggest that quasars must be nearby — within a few million light-years — so their energy output can be theoretically reduced to explainable levels.

Now the dilemma seems to be partly resolved. According to two Hale Observatories' astronomers, quasars are actually monstrous explosive events inside apparently normal but distant galaxies.

For the first time, J.B. Oke and James Gunn of the California Institute of Technology have been able to prove that the aura of faint light around a brilliant quasarlike object is really a galaxy of ordinary stars. The crucial evidence was gleaned from a spectrum revealing the starlike composition of the "fuzzy" light around the quasar named BL Lacertae.

The new discovery climaxes four years of observations of BL Lacertae by Oke and Gunn. For half a century this object in the small constellation Lacerta has been listed in astronomical catalogs as a variable star — a star that varies in brightness. (In fact, the designation "BL" signifies a variable star.)

Interviewed by ASTRONOMY, the two Caltech astronomers asserted that the object they have analyzed is so like other quasars in terms of its behavior and total luminosity that either the other quasars are like it — that is, embedded in galaxies — or they are an entirely different type of object that mimics BL Lacertae.

An occulting disc on the 200 inch telescope at Mt. Palomar screened out the bright central image of BL Lacertae. Further electronic processing removed noise and allowed Oke and Gunn to identify absorption lines of a typical near spherical galaxy made up of old stars, and relatively dust and gas free. Thus BL Lacertae is identified as a quasar at the center of an old galaxy. Although BL Lacertae exhibits the same light and radio periodic fluctuations as a typical quasar, earlier attempts to obtain a line spectrum were unsuccessful.

continued on page 45

National Environmental Satellite Service Photograph

The storm system that spawned destructive tornados over the south and midwest on April 3, 1974 is seen in this photo taken by NASA's Applications Technology Satellite (ATS) from its stationary position at 70 degrees west longitude. The photo, taken at 2 p.m. CDT, is one of about 30 such pictures obtained daily by the ATS from its perch 22,300 miles above the Atlantic Ocean.

Unusual Astronomical Maser Discovered

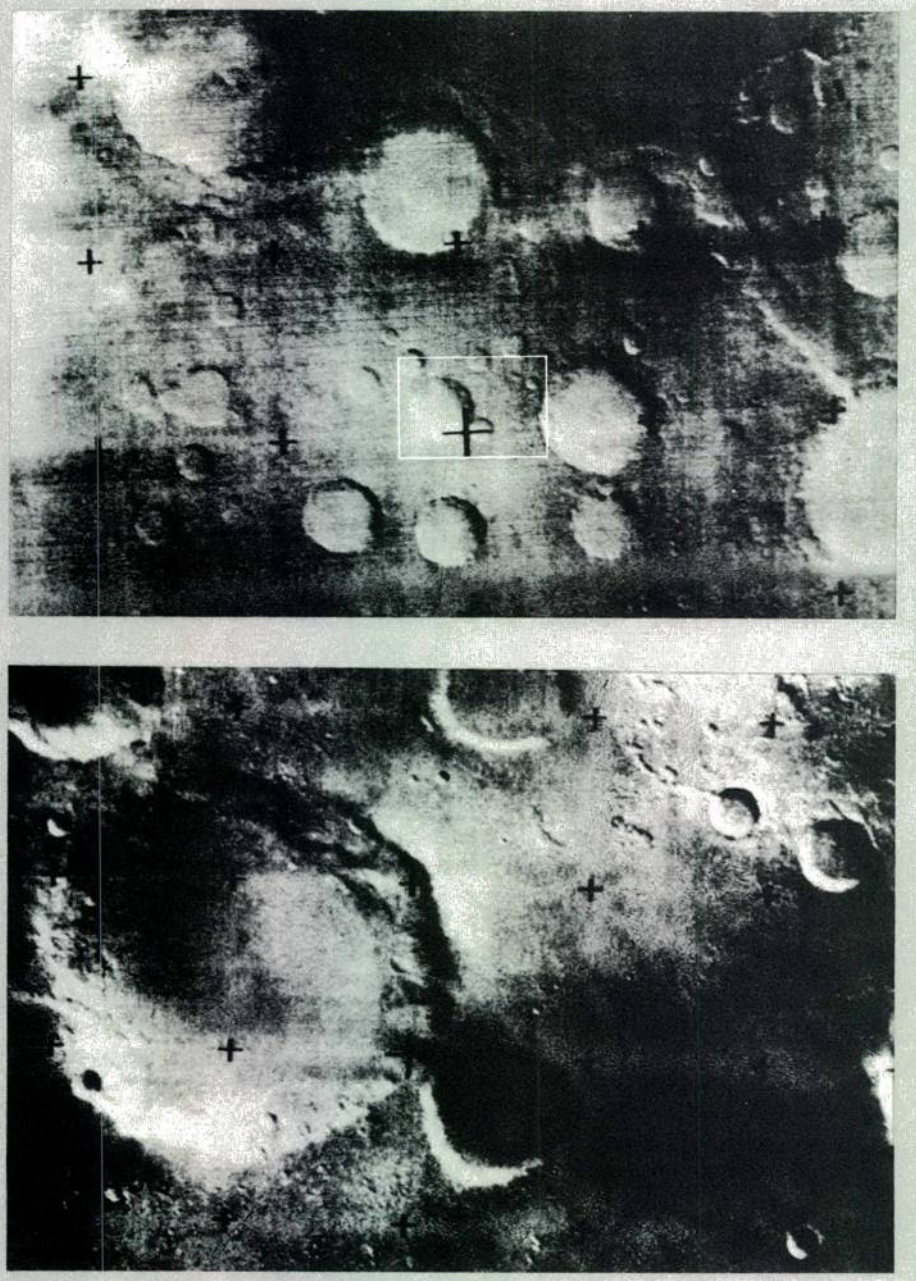
Radio astronomers who look at molecules in interstellar gas clouds and nebulae have experienced an extraordinarily rich harvest with the detection of some two dozen compounds since 1968. Prior to this time only OH, the hydroxyl ion, had been seen at radio wavelengths, and it was thought that the interstellar medium was so sparse as to have only hydrogen and a few simple diatomic molecules in modest abundance. This prediction has proved wrong with the recent discovery of such exotic and complex substances as formaldehyde and methyl alcohol (the latter compound being the essential intoxicant of "white lightning").

These newly discovered molecules are seen in abundance in cool, dusty regions where the temperature is only 20 or so degrees above absolute zero. Water and OH are modest exceptions, being observed to radiate as natural masers (the radio frequency counterpart of a laser) in the atmosphere of cool stars and near the periphery of bright nebulae. Even here, however, temperatures are still cool — probably only around a couple of hundred degrees above absolute zero (approximately −150 degrees Fahrenheit).

It was also thought that molecules would not be found in hot regions where ultraviolet radiation could easily destroy the weak molecular bond. Although this assertion is certainly, in some measure, true, the heavens have once again confounded the conventional astronomical wisdom. Drs. Lew Snyder and David Buhl working at the National Radio Astronomy Observatory have detected a strong maser source in the Orion molecular cloud. Subsequent observations by Dr. John H. Davis' group at the University of Texas conclusively identify this emission as coming from silicon monoxide (SiO), one of the rarest astronomical molecules and the only one containing silicon.

The extraordinary thing about this radiation is that it originates from what chemists call an "excited vibrational state" of SiO. To have the molecule in this very energetic state implies temperatures of nearly 2,000 degrees Kelvin — almost 2/3 the surface temperature of the sun! This is an extremely hot environment for an interstellar molecule and has forced astrophysicists to reexamine their ideas on the energetics of molecular radiation.

NASA's Pat Thaddeus, one of Davis' collaborators, suggests SiO may be exceptional because of its very low volatility. This would make it probably the only interstellar molecule able to exist in reasonably hot temperatures, suggesting that this strong maser emission may be well localized near an infrared star — a star that is very young and has not yet evolved to the higher temperatures of "normal" stars. Such objects are known to exist in the Orion nebula and could account for the excitation energy which produces this exceptional molecular maser. Further investigation of this new and unexpected phenomenon may bring us closer to an understanding of the environment within the nebula.



Tass from Sovphoto

The craters of Mars were photographed by the Soviet Union's Mars 5 spacecraft that achieved orbit about the red planet on Feb. 12. The robot vehicle is in a looping orbit that carries it from a near point of 1,056 miles out to 19,500 miles from the surface of Mars. During one of its swings close to the surface, the craft's two cameras took the wide angle view (top) and a high resolution shot of the boxed area. The large crater in the close-up view (bottom) is about 25 miles wide and has wind eroded slopes. Even more erosion can be seen in the craters in the wide angle photo that spans 400 miles of Martian landscape. Of particular interest is the channel at upper right of the top photo. The Soviets believe running water was responsible for the formation of this and similar features.

Robot Eye to Scan Earth

An unmanned spacecraft called Earth Resources Technology Satellite (ERTS) has been scanning our planet for over two years, reporting on snow pack in winter, range grass in summer, crop damage in spring, harvest in fall and pollution the year round. Camera laden aircraft and ground observers can do many of these tasks. But airplanes must take hundreds of photos to cover the area a spacecraft sees in a single pass.

Now there are plans to do the job even better, with a new generation of spacecraft called Earth Observatory Satellites, or EOS. Two would be launched in 1978 and 1979 atop conventional rockets. Later versions would fly in the Space Shuttle's cargo bay.

Today's Earth-studying satellites see only the patch of land directly below. The EOS breed will carry new "pointable" instruments that look in many directions. They can scan preplanned targets, perform tasks like hurricane or flood assessment, or report the spread of some new crop disease.

The first EOS will be dedicated to land management studies. The second may study weather and the world's oceans. Later versions will report on such things as pollution

How useful is the view from space? Working with ERTS pictures, scientists have discovered cattle forage in Arizona deserts, oil reserves in India, damage to Canadian forests from sulfur dioxide, new timber in California, and the breeding site of desert locusts in Saudi Arabia.

QUASAR PUZZLE *continued from page 43*

Spectra can be obtained from most quasars from the heated gas clouds around them. The astronomers explained that the previous inability to get spectra from BL Lacertae's quasar could be due to a lack of gas clouds in its vicinity. (Normal spherical galaxies have very little gas in them.)

The combination of occulting disc and electronic manipulation of the remaining light permitted Oke and Gunn to identify absorption lines despite the paucity of gas in the spherical galaxy. They were thus able to deduce a redshift and calculate a distance of one billion light-years for BL Lacertae.

The significance of their work is that BL Lacertae is an old galaxy, perhaps 15 billion years old. "It appears that quasars can occur in old as well as young galaxies, and may occur several times in the lifetime of a galaxy," Oke said.

Like many quasars, BL Lacertae varies rapidly in brightness, sometimes from night to night. Flickers only two minutes in duration have been reported. It is assumed that the variations come from the central quasar. Its radiation in the radio frequencies also varies, but on a month-to-month basis. There is no correlation between optical and radio variations. The light varies 8 to 10 times in brightness — roughly from 13th to 16th magnitude. The rapid variability of light and direct measurements by radio telescopes indicate that the diameter of the bright quasar is less than one light-year, which is very small compared with the diameter of its galaxy (more than 100,000 light-years).

If BL Lacertae wasn't so near to us, compared with the distances of other quasars, and if the bright central object had not been dimmer than usual, it might not have been possible to obtain the spectra, the Caltech astronomers said. The dimmer light from its stars might have been overwhelmed by the quasar's brilliance.

"Dr. Maarten Schmidt (of Caltech and the Hale Observatories) has shown that the more you look into the past (by observing objects at increasing distances) the greater the density of quasars," said Oke. "Since galaxies were younger then, it is tempting to suppose that galaxies become quasars much more often when they are young. It may be a pretty rare event for old galaxies."

The quasar appears to be a violent kind of event that is triggered in the nucleus of a galaxy. The question is: What starts the whole thing?

Gunn suggested that the quasar might form as gas falls to the center of such an elliptical galaxy. In spiral galaxies by contrast, the gas emitted by stars as they attain red giant status remains supported in the spiral arms. But in an elliptical galaxy this same gas quickly loses momentum and falls toward the center. While stars of an elliptical or near spherical galaxy move about like a swarm of bees and rarely collide, not so the gas clouds. They collide with each other and lose momentum. So a central mass could very well build up to a critical stage at which some as yet not understood process triggers the quasar reaction.

It might also be that the mass concentrations result in a black hole which is pulling in stars too, or causing the collision of stars as they congregate in the central regions.

"Perhaps quasars are relief valves for galaxies to spurt off excess energy," suggested Oke. He cited several of the Seyfert galaxies that could possibly represent galactic configurations following a short burst of quasar energy. We have no idea how long a quasar shines, he added; they could be relatively short-lived events.

The astronomers said there is some understanding of the mechanism that radiates and produces the intense quasar light. It comes from electrons that have been ejected with tremendous velocities and are spinning around magnetic fields. But what drives the whole thing? That is still the big question, they said.

Earth is a Radio Emitter

We have known for many years that Jupiter is one of the strongest emitters of very long wavelength radio waves. Jupiter radiates its strongest burst-like radio signals at wavelengths of tens of meters (a frequency of 20 to 30 MHz).

Now satellite-borne experiments have found that even longer wavelengths, on the order of kilometers, are being emitted by our own planet. The total power emitted by this radio source, located in the auroral regions above Earth's atmosphere, is about one billion watts — comparable with the strong radio signals emitted by Jupiter.

This discovery was made from the IMP 6 and 8 satellites which are in highly eccentric orbits about Earth. At their closest approach they come to within about 4,000 miles of Earth and at their farthest they swing out to 150,000 miles. The radio receivers on board are connected to an antenna 100 yards long which is capable of picking up radio frequency signals down to 30 KHz.

Earth appears as a strong radio source around 200 KHz, which is below the bottom end of the normal broadcast band of our radios. The radio signals from the auroral regions at this frequency cannot penetrate down to Earth's surface, because of the shielding effect of the ionosphere (which is why the radio astronomy experiments at these frequencies had to be launched above the atmosphere to start with).

As is the case for the Jupiter emission, Earth's kilometric radiation occurs in sporadic "storms" of radio signals closely correlated with auroral activity. This new discovery was recently communicated by D.A. Gurnett of the University of Iowa.

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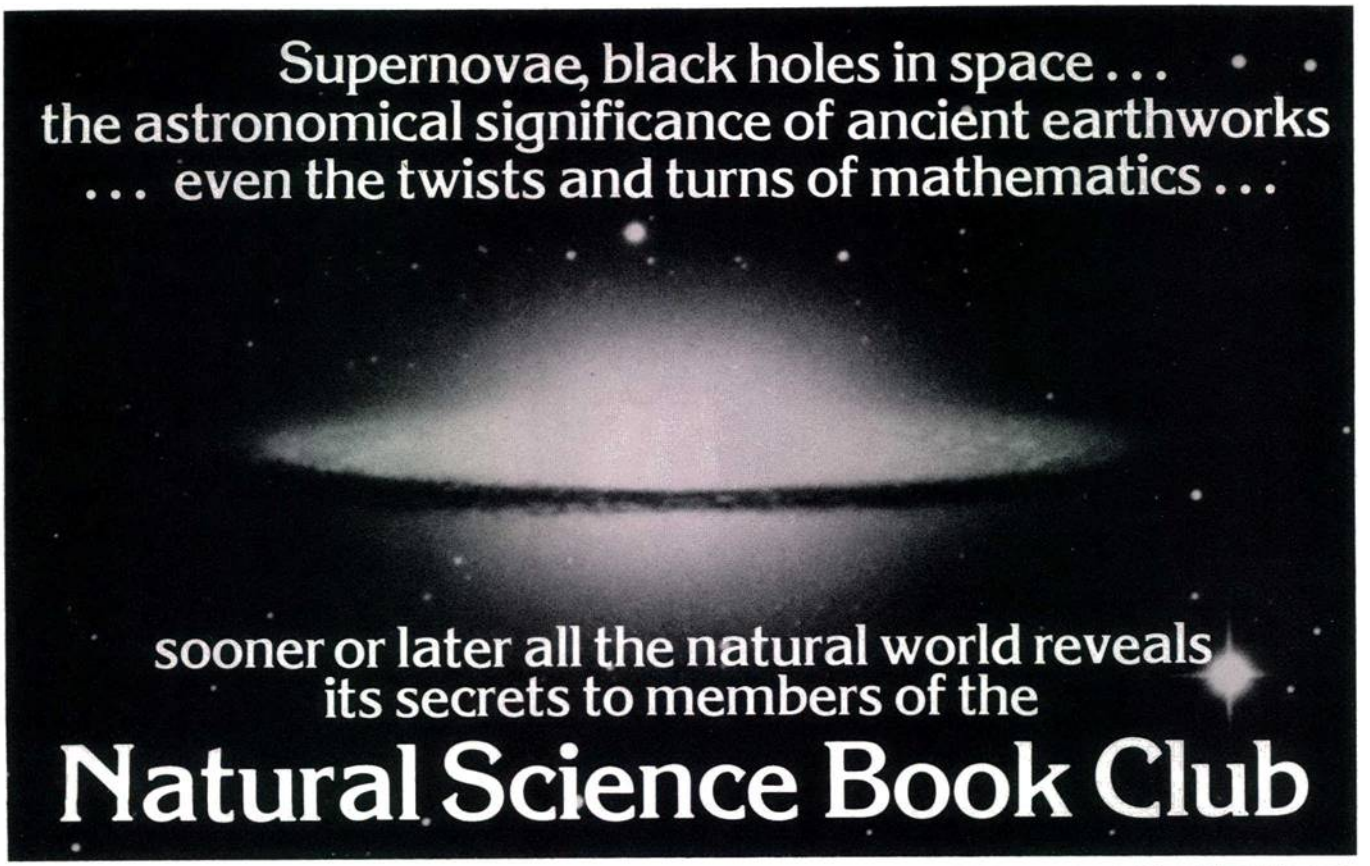
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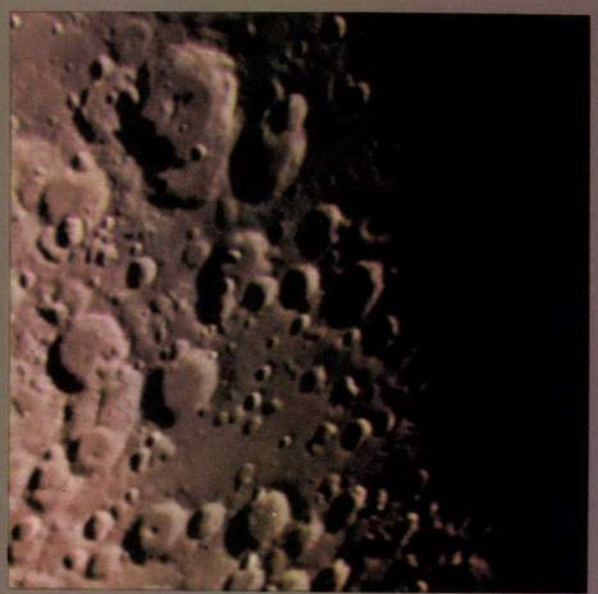
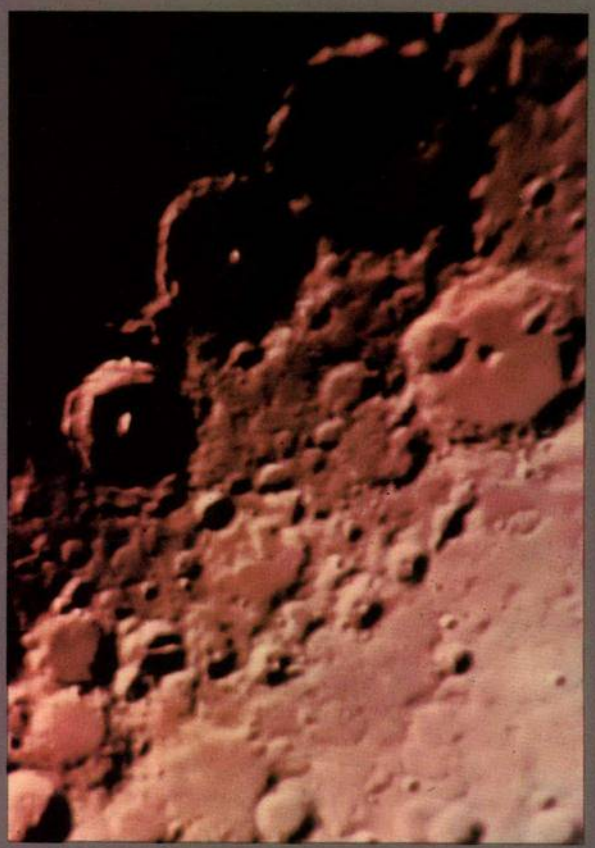


Maurolycus and nearby craters by Steve Reed



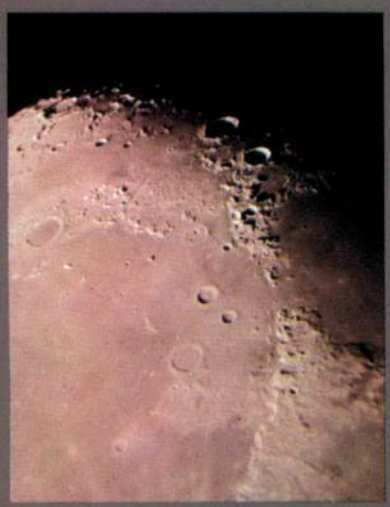
Alphonsus and nearby craters by Steve Reed

Gibbous Moon by Steve Reed

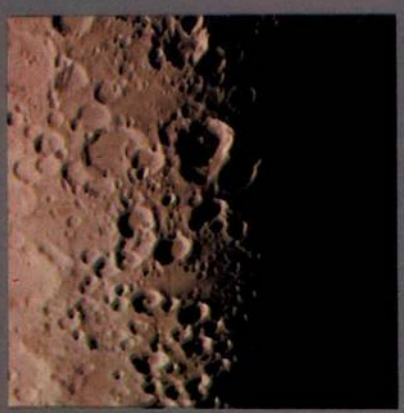
Lunar Halo by Don Dean

STAR GALLERY '74

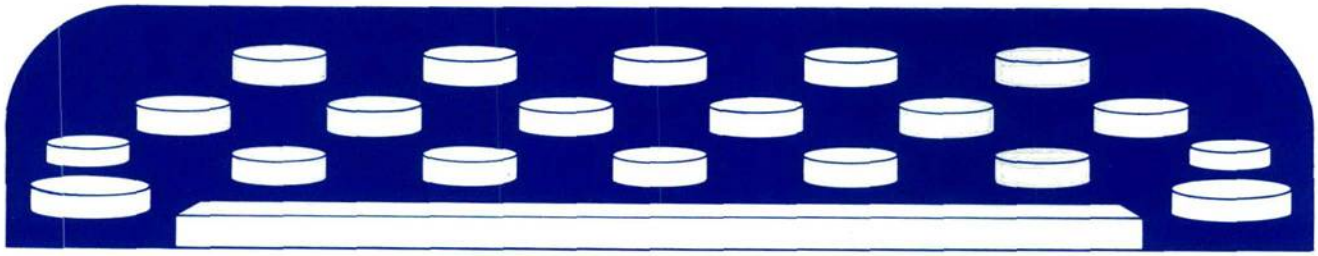
This occasional department is devoted to some of the best color astrophotographs we receive over a period of months. They are generally made by amateurs with easily available equipment. Payment for use of these photos is $10.00 each.



Mare Imbrium by Steve Reed



Maurolycus and nearby craters by John Sanford



IN FOCUS

Sir / I would like to ask your help on an observation. On March 27, 1974 I was trying to find the constellation Aries. After finding Triangulum shortly after dusk in the eastern sky, I looked to the south a little and saw Aries.

I then focused my 7 x 50 binoculars on Hamal in Aries and by chance spotted what appeared to be a smudge between Theta and Eta, south of Hamal. The longer I looked at it the more defined it became until it took on the shape of, to my surprise, a comet — similar to what I saw of Kohoutek. I charted its movement for a few days and it seemed to be moving through Aries toward Triangulum.

Was this in fact a comet and if so has it been previously observed?

DAN ASHCRAFT

Stillwater, Ok.

Mr. Ashcraft / You actually stumbled on Comet Bradfield. The reason you didn't know about it is explained in Sky Almanac this month.

Sir / I have just finished reading Sky Almanac (April) and would like to thank you for cleaning up its format. It used to look so complicated that I didn't even try to figure it out; now it's straight forward and easy to use.

MICHAEL P. KIRKPATRICK

Vancouver, Wash.

Mr. Kirkpatrick / You and many other readers commented on our new chart format in Sky Almanac; the response is three to one in favor of the new charts. Thank you. A number of persons also reminded us of our substitution of B (Mercury) for C (Mars) in that issue. We'll try harder.

Sir / We were using my friend's telescope to look at the sun. We had a filter at the eyepiece and it melted. It was a special sun filter. Could you tell me what happened?

MARK PICCARRETO (age 9)

Webster, N.Y.

Mr. Piccarreto / Despite what telescope manufacturers say, the editors of ASTRONOMY do not recommend use of sun filters that fit on (or into) the telescope eyepiece. The results can be disastrous as you discovered. The heat build-up at the eyepiece is intense when sunlight is focused there. Full aperture filters that cover the front end of the scope are best. See page 19 of the November 1973 issue for details.

Sir / I observed what looked like a comet through my 7 x 50 binoculars near Gamma Triangulum on March 30 and 31. Through my three inch telescope at 38 and 84 power it still looked like a comet, but it was difficult to see any definite detail.

Do you know the name of this comet? Or is it not a comet? Since it moved in relation to the stars, I know it is not a nebula.

JAMES W. GREEN III

Winnsboro, S.C.

Mr. Green / Congratulations on your independent "discovery" of Comet Bradfield. Regular sky observers such as yourself will probably want to make use of **Instant-News** *(see Sky Almanac).*

Sir / The topics of your feature articles are always interesting, and the articles are well written with the exception of one point: They are too short. They go just far enough to give you a background and thoroughly whet your appetite for the subject. Then they leave you there, having only skimmed the cream of the topic. I realize that ASTRONOMY is not **Scientific American** and must appeal to a wide audience, but I still think the articles could be quite a bit meatier without becoming obscure.

CHARLES PARKER

Wilmington, Del.

Mr. Parker / We hope "Planetary Bonanza" quenches your thirst for long articles.

Sir / Under optimum conditions the smallest telescopes can give surprisingly good views of Saturn. On March 6, 1974 I observed Saturn with a 60mm refractor, and was able to discern features which are normally revealed only by larger instruments.

Seeing conditions at the time were excellent with the image remaining steady almost continuously. A slight haze and the moon nearing full phase made sky transparency only fair, but also reduced the brilliancy of the planet and brought out finer detail.

At 100x Cassini's division was easily seen at the two points where the rings project farthest from the planet. The shadow of the ball against

the rings gave a strong relief effect to the southeast limb.

Using the same magnification, a belt was seen bordering the southern edge of Saturn's equatorial region. It appeared broader near the planet's central meridian, tapering and fading out completely as it approached the edges of the disk. The belt was darker in hue and had a slight orange tint in comparison with the planet's pale yellow color.

Perhaps these observations may encourage other small telescopes users who hold the view that at least a four inch instrument is needed to show similar features, as was stated in the December 1973 issue of ASTRONOMY.

RAYMOND GLASSFORD
Kankakee, Ill.

Mr. Glassford / We are pleased to hear of your impressive observations. Half of our readers will see more than we say they should and half will see less. We try to make statements that will apply to the "average" observer, telescope and atmospheric conditions.

Sir / Often the terms "rich field" and "richest field" are used with reference to telescopes. Where can I get a complete explanation of the terms and how to go about determining the relative merits of the various small (up to six inch reflector) telescopes on the market?

ALBERT S. BLOOD
Augusta, Me.

Mr. Blood / We get many inquiries such as yours. Next month the first installment of "Equipment Atlas" will appear in ASTRONOMY. This department will be devoted to the use of your telescope; we will compare different types of scopes and discuss how to set up a telescope, how to use setting circles and more.

Regarding your specific question, "richest field" telescopes are short focus, wide field instruments used mainly for viewing star clusters and nebulae. Optimum aperture is four to six inches with f/4 to f/5 focal ratios. These scopes are compact and give breathtaking views of the Milky Way but are often disappointing when turned to the planets.

ASTRONOMY

Index to Vol. 1

In response to requests from our readers and schools, ASTRONOMY has just published a cumulative index to Vol. 1. This subject index covers August, September, October, November and December, 1973, which includes issue Nos. 1 through 5. Index to Vol. 1 is available for $1.00 each, including handling and first class postage.

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Observing Mercury

Artwork by Victor Costanzo

Under the most favorable conditions, dusky markings have been seen on Mercury by highly experienced planetary observers using large and optically excellent telescopes.

Of the five planets visible to the unaided eye, Mercury is by far the most difficult to observe. Some astronomers have lived their entire lives without having seen it. But the first two weeks of this month offer a rare chance to get a good view of Mercury. Not only is it relatively easy to find because of its apparent nearness to Saturn, it is also in a favorable position for viewing from the United States and Canada in a month when weather conditions are ideal for evening viewing.

Mercury is very seldom conveniently visible in the evening. Usually only once a year does it make a good appearance like it does early this month. Mercury takes 88 days to zip around its tight little orbit and during that time, Earth goes only 1/4 of the way around the sun. So to us, Mercury seems to dash from east of the sun to west of it as the little planet swings from one side of its orbit to the other.

When Mercury is east of the sun to its maximum extent, we see it as an evening star low in the west. When it is west of the sun, we can view

it as a morning star in the east before sunrise. But because of some interesting geometry involving the tilt of Earth's axis and Mercury's orbit we get better views of Mercury at certain seasons than at others. It works out that the best time to see Mercury in the evening is in the spring and the best time to view it in the morning sky is in the fall — at least from the northern hemisphere.

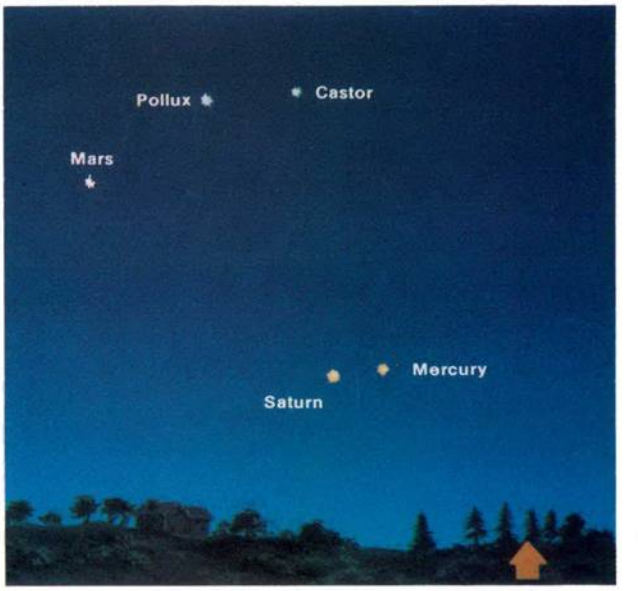
Since virtually everyone finds it more convenient to view Mercury in the evening, the one spring "elongation", as it is called, is the time when most astronomy enthusiasts do their Mercury hunting. So this is it. And as we mentioned earlier, the fact that Mercury appears near Saturn makes the two planets easy to find. The diagrams on this page show Mercury's position in the evening sky relative to Saturn and the horizon.

The best time to make sure you spot Mercury before it dips below the western horizon is about 45 minutes after sunset; look toward the west for an object not quite as bright as Saturn, and fairly close to it. The two planets will be by far the brightest objects in that part of the sky so identifying the two of them will mean that you've got two planets and it's a matter of distinguishing one from the other. You should be able to do this by referring to the diagrams here.

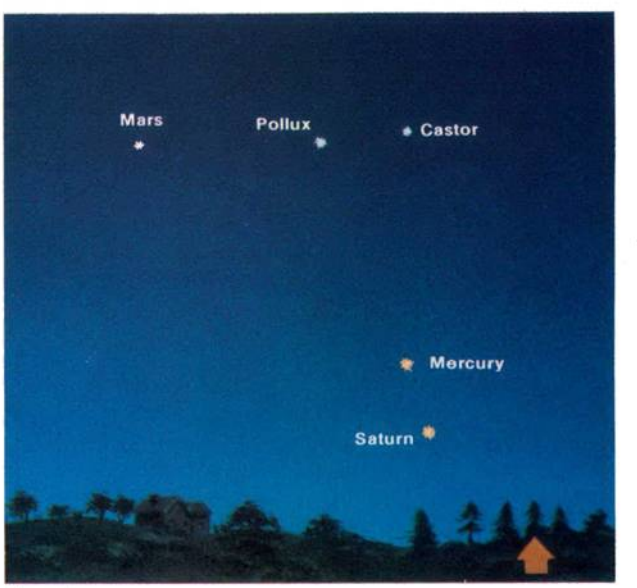
Mercury will be at its maximum apparent distance from the sun for the entire first week of June and this is the opportune time to hunt for it. During the second week of June it's almost as far away from the sun but somewhat fainter, so it will not be as easy to see. In addition Saturn will have dipped lower toward the horizon making it less conspicuous, and the double planet appearance will have vanished. After June 15, it will be difficult to pick up either Mercury or Saturn.

If you have a fairly unobstructed western horizon you will find it easy to locate Mercury. The satisfaction will be yours, especially if you've never seen the fleet planet before. But if you choose to turn your telescope toward Mercury you're faced with a challenge that has frustrated many astronomers over the last century.

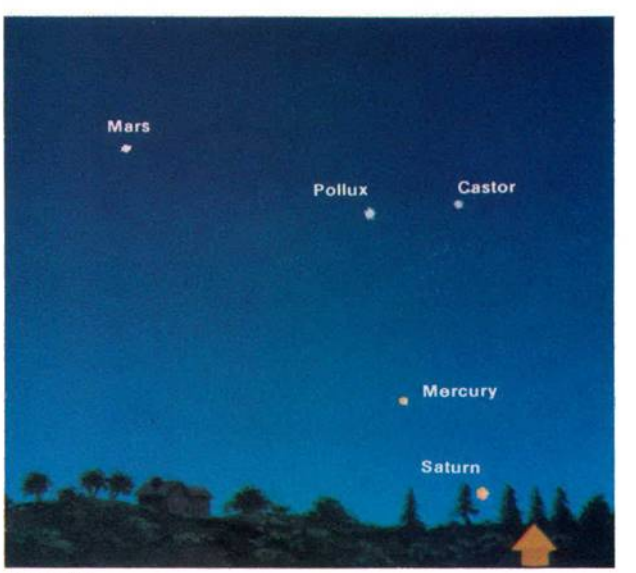
The challenge is to see something — anything — on the planet. Just turn your telescope toward Mercury and you'll see what we mean. First of all you have to look through the turbulence of Earth's atmosphere which is at its worst when looking at something not very far above the horizon. Even under the best of conditions Mercury



June 1



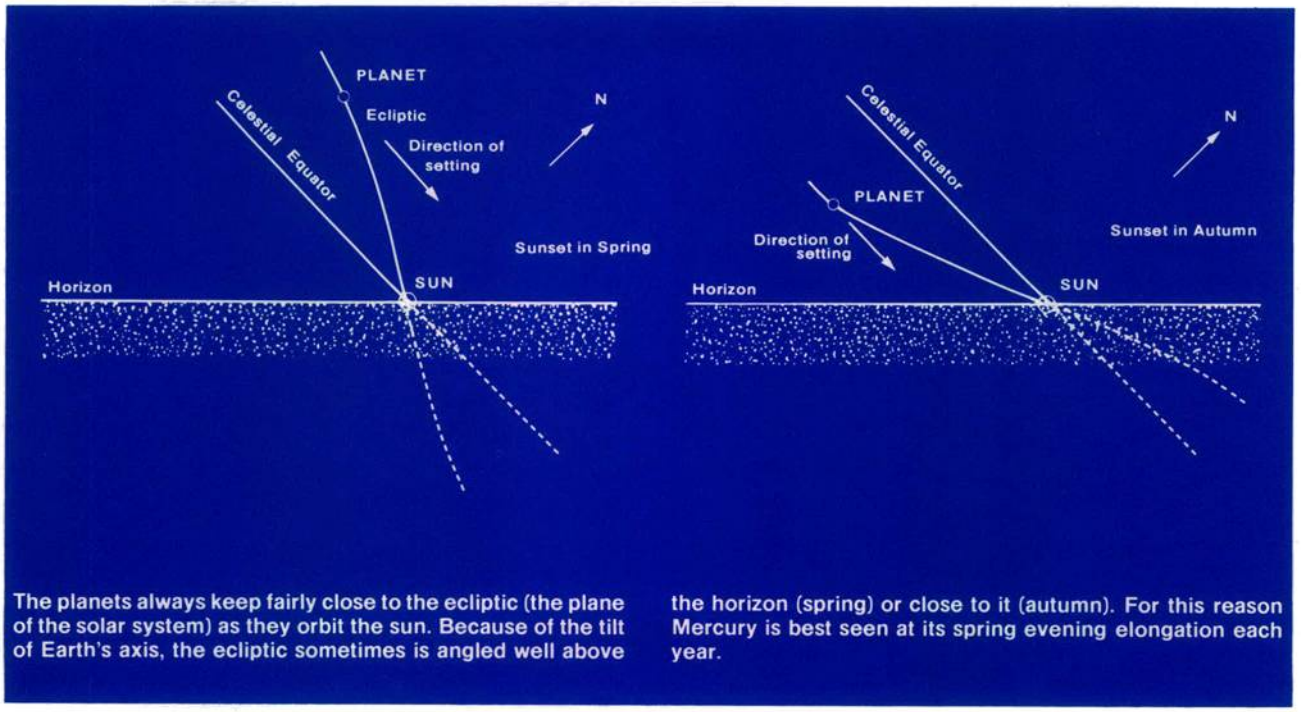
June 6



June 12

About three-quarters of an hour after sunset on the dates indicated, Mercury should be easy to locate using the reference stars and Saturn as guides. The arrows indicate sunset point so you will be looking just north of west. Haze or horizon obstructions will impair your hunt for Mercury.

Artwork by Victor Costanzo



The planets always keep fairly close to the ecliptic (the plane of the solar system) as they orbit the sun. Because of the tilt of Earth's axis, the ecliptic sometimes is angled well above the horizon (spring) or close to it (autumn). For this reason Mercury is best seen at its spring evening elongation each year.

is only about 20 degrees above the horizon at sunset and by the time it's dark enough to easily locate the planet it's usually 15 degrees or less from the horizon.

So we have a problem. When it's easy to find Mercury, it's too close to the horizon. When it's farther from the horizon the sky is too bright to locate the planet.

There is a solution to this problem, and that is locating Mercury during the daytime when it is higher in the sky. This generally requires the use of setting circles on a permanently mounted telescope and is usually a project for the more experienced astronomy enthusiast. We won't get into it further this month.

For the majority of us who do not have permanently mounted telescopes and setting circles, we have to try an alternative which in the long run is probably the most satisfying method of observing Mercury. Immediately after sunset, using your telescope's finder or a pair of binoculars, sweep in the general area where you expect to find Mercury. Usually within 10 or 15 minutes after sunset you will have found the planet. The sky will still be quite bright, but Mercury being bright too makes it a fairly easy binocular or finderscope target.

Once in the cross hairs of the finderscope, the main telescope can be brought to bear on the planet. Mercury will be nicely contrasted with the deep blue sky in the telescope's field of view. Usually 30 power for each inch of your telescope's aperture is suitable for observing Mercury. With the deep blue sky as a backdrop the conditions are perfect, because in a black sky Mercury is often dazzlingly bright under high magnification. By the time Mercury is against a black sky Earth's rotation will have carried it down closer to the horizon where atmospheric turbulence is at its worst.

So there's the crucial time between about 20 and 50 minutes after sunset when Mercury will be adequately high above the horizon in a deepening blue sky, and relatively easy to find with the help of a finderscope or binoculars — all adding up to the prime time for Mercury observing. It's really not much of a window — 30 minutes of useful observing time. What can you expect to see?

If you're familiar with the appearance of Venus in a telescope you will have some idea of what to expect on Mercury. The phases of the two planets are similar for the same reasons. Mercury, being a planet closer to the sun than Earth, often presents its nighttime side to us, and that's what it's doing during the early part of June.

On the 1st we see almost a half Mercury with 48 percent of the planet's illuminated side visible to us; the 3rd, 42 percent, and by the 8th, we see only 32 percent. Mercury's apparent diameter increases during this period however, because as the planet swings toward us in its orbit we see more and more of its unilluminated side. All this results in a diameter increase from 7.3 seconds of arc on the 1st to 7.7 seconds on the 3rd and 8.6 seconds on the 8th. By June 13, probably the last day of convenient viewing, the diameter has increased to 9.6 seconds and the phase has dwindled to 22 percent.

Mercury's magnitude also falls off as its phase angle decreases. Its magnitude on the 1st is +0.3, but by the 13th it has dropped to +1.3 — a full magnitude or 2-1/2 times fainter. After the 13th, Mercury rapidly drops in brightness and also moves in closer to the sun and becomes difficult to detect.

"After decades of straining to see the markings of Mercury's pinkish disk, we have relatively little to show for our effort," said long time Mercury observer and planetary scientist Clark Chapman of the Planetary Science Institute in Tucson, Ariz. But he added, "It has taken a major NASA effort to do better than we did with our small telescopes."

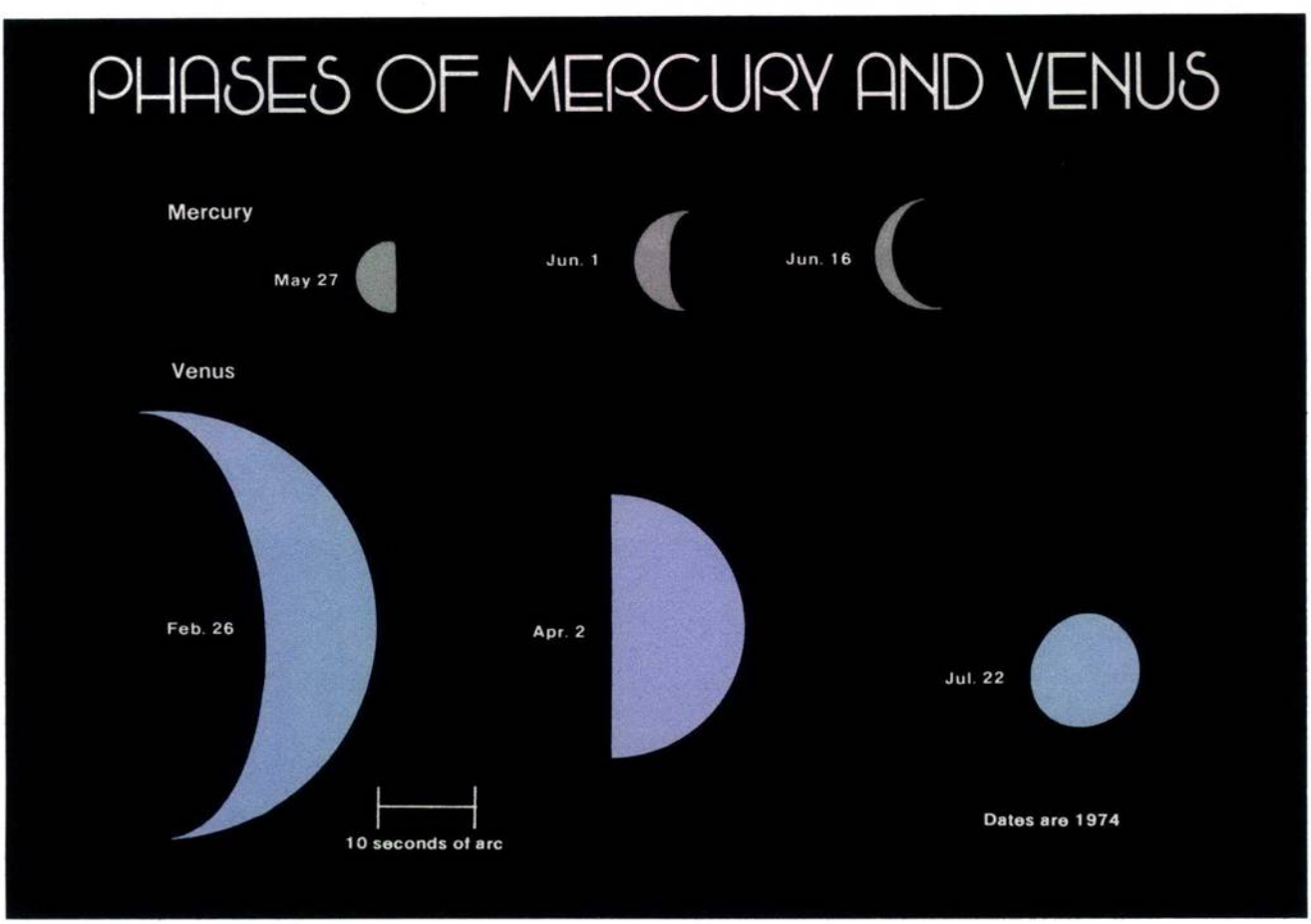
Detailed comparison of the Mercury map shown here with the Mariner 10 photos is only now beginning, but it can probably be said that the day of the dedicated amateur making scientific contributions to our knowledge of Mercury is now over. (Another planet bites the dust!)

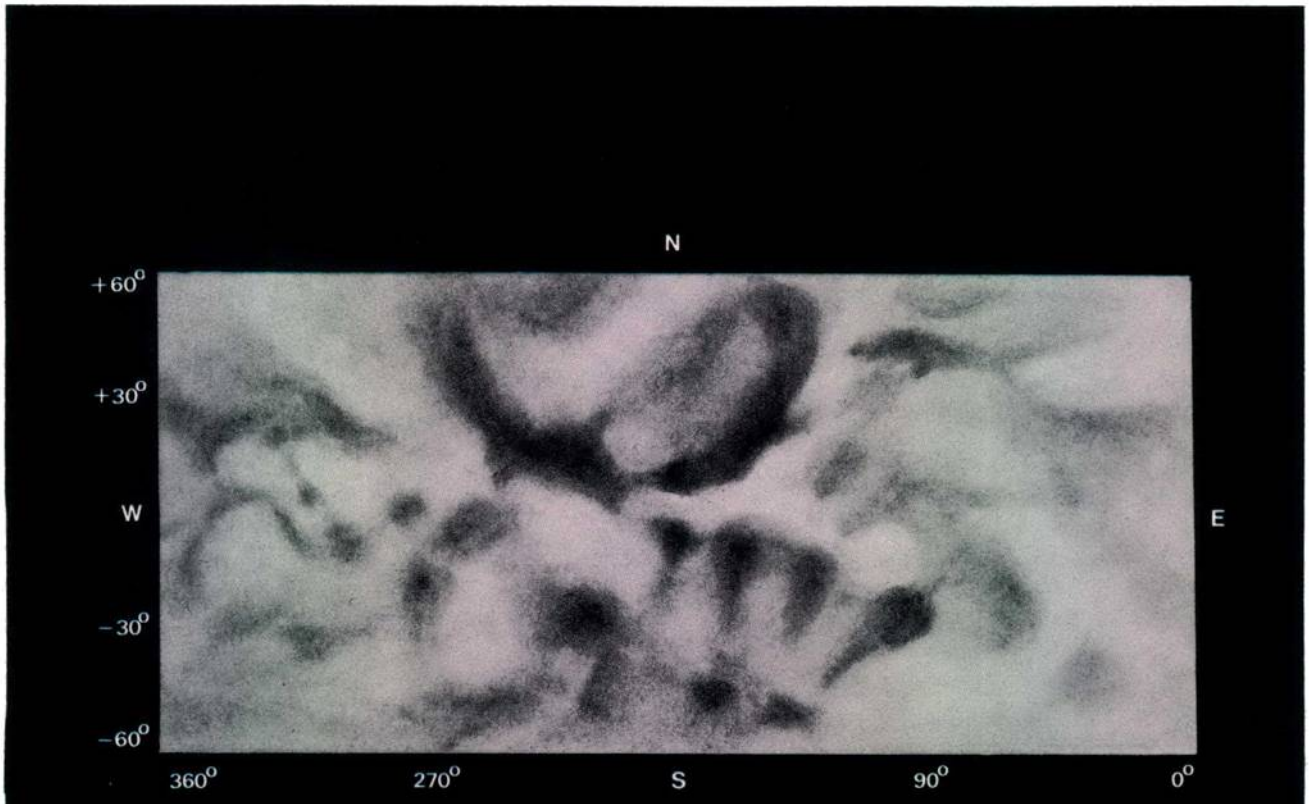
To get an idea of the Mercury observer's dilemma take a look at the crescent moon through the wrong end of low powered binoculars. That's a good simulation of a high resolution telescopic view of Mercury under favorable conditions. For unfavorable conditions the simulation should include holding a lit cigarette lighter a few inches below and in front of the binoculars.

Most observers see Mercury as a shimmering crescent without detectable surface features. It takes many hours of experience and excellent seeing conditions to begin to see anything at all on the planet even using the largest telescopes. But experienced telescope users working with four inch or larger instruments have recorded dusky markings and occasional bright areas on the planet.

Because of Mercury's peculiar rotation period (see page 8) the same side of the planet faces the sun at every second perihelion passage (closest approach to the sun). We didn't always know this. Until a series of historic radar discoveries in 1965 that uncovered the rotation period, it was generally believed that the same side of Mercury perpetually faced the sun. Drawings made by competent observers in the first two-thirds of the 20th century seemed to prove the fixed aspect of Mercury.

As mentioned earlier, Mercury is usually only well seen in the evening for a brief interval a few weeks once each year. Similarly in the morning it is well placed for only a short period annually. So if you were trying to map the planet you would use these favorable times.





The world's finest photographs and visual observations, mainly from New Mexico State Observatory and Pic-du-Midi Observatory in France, have been combined to produce this map of Mercury's surface features. Until the Mariner 10 mission this was all that was known about the planet's appearance. The map is believed to be most accurate around 120 degrees to 180 degrees, and also from 300 to 330 degrees where the mapmakers had the most observations to work with. The half of Mercury seen by Mariner extends from about 20 to 200 degrees. Artwork by Victor Costanzo

That's what the earlier observers did and they saw the same markings almost every time. Yet Mercury does rotate. What's going on? It seems to be a remarkable coincidence. Let's take an example.

Suppose we make a series of drawings of Mercury on several dates in the first two weeks of this month while the planet is in view. Then we save them to compare with the features recorded in future observations. Assuming we only observe in the evening, the next good opportunity will be mid-May 1975, then early May 1976, mid-April 1977 and so on. Actually these prime sessions are 348 days apart. By remarkable coincidence Mercury makes two of its 176 day rotations in only four days longer than that — 352 days. So you end up viewing virtually the same side of Mercury once every year during its favorable evening elongation (for about six years in a row). If you were making a map of Mercury you would assume — as Antonaidi, Dollfus and other great Mercury observers did — that since you saw the same features, the same side faces the sun all the time. Clark Chapman calls the coincidence "Mercury's April Fool's trick".

But that's all history now. It's not likely you will want to make a complete map of Mercury anyway. Drawing what you see on the planet on one or two occasions can be challenging. The task is to see anything at all. Try it. See what Mercury looks like in your telescope.

(A good summary of observing techniques for serious observers and a very thorough bibliography are contained in the booklet, **An Observer's Guide to Mercury**, available for $2 from Richard G. Hodgson, Mercury Recorder, ALPO, Dordt College, Sioux Center, Iowa 51250.

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The detailed cover photograph of ASTRONOMY's March issue is now a colorful, 17 x 22 inch blow-up poster. A host of celestial objects at our galaxy's core are recorded in full color in this breathtaking photograph by Orien A. Ernest. The gossamer, golden beauty of the Sagittarius star clouds is revealed in magnificence unsurpassed by any other color Milky Way photograph. This beautiful lithograph is available framed as above or unframed.

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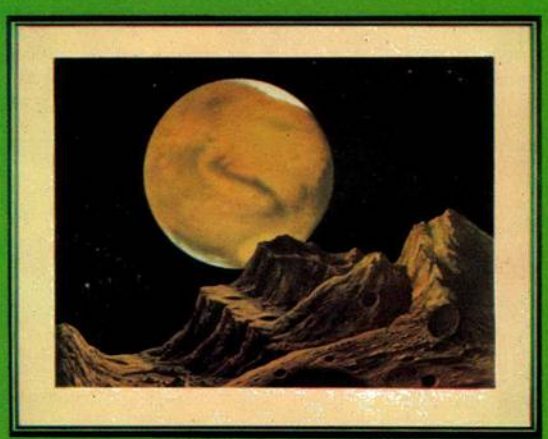


Mars as Seen From Deimos

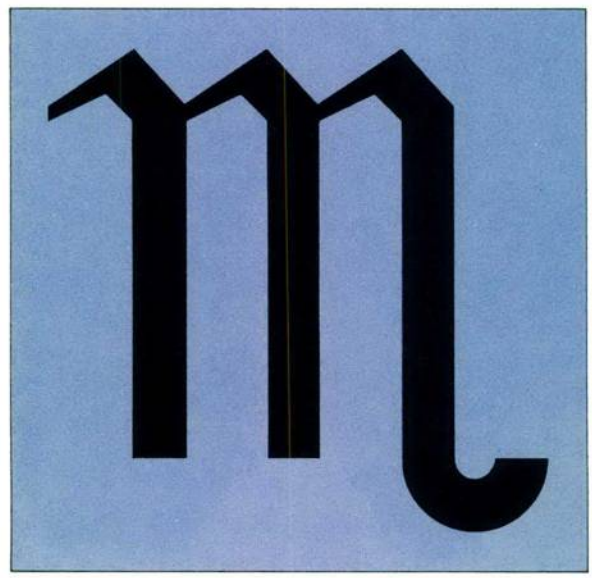
The artistic imagination of Victor Costanzo is boldly displayed in this 17 x 22 inch full color lithograph of the red planet Mars as it would appear from its outer satellite Deimos. Costanzo's painstaking accuracy in this rendition is given further credence because he incorporated real constellations in the sky background. To the lower left of the planet is the Hyades star cluster in Taurus, and to the upper right is the constellation Aries. This artwork was first used as a two page spread in ASTRONOMY's May issue to illustrate "The Lost Pictures of Mars" by Carl Sagan. It is available framed as above or unframed.

CONSTELLATION CLOSE-UP

Scorpius

by

Thomas C. Bretl



Summer weather is always accompanied by the rising of Scorpius in the southeast. The ancient scorpion is rich in the relatively "local" wonders of our own Milky Way galaxy. If it were not for its extreme southern declination which keeps the constellation close to the southern horizon, Scorpius would certainly be one of our favorite regions of the sky to explore in great detail. Open and globular clusters of every shape and size, brilliant double stars, and even curious "empty" regions in the sky all abound in this well-known constellation of the zodiac.

Much of Scorpius lies far south of the celestial equator, however, and this presents a definite

problem for observers in northern latitudes. Its low altitude often results in very bad seeing conditions, leaving double stars hopelessly unresolved and star clusters disappointingly paled against a bright background sky. Unfortunately, with parts of it only barely rising above the southern horizon, many observers in the United States will never have a chance to fully appreciate the wealth of clusters that populate the Milky Way as it winds its way through the scorpion's tail.

Despite this disadvantage, Scorpius should certainly not be ignored. The objects to be found in the southern part are well worth the wait for a night of exceptional transparency, and the northern part of the constellation — much more easily observed — is almost equally endowed with objects of great beauty and interest.

On any clear summer night, the first star visible in the southern skies is Antares (Alpha Scorpii); with its brilliant sparkling color it is a worthy first stop on any observational excursion through this part of the sky. Antares is a first magnitude star, the 15th brightest in the heavens, and its fiery red color is unmistakable. It belongs to the class of "red giants", and is so large that if placed at the center of our solar system it would easily extend far beyond the orbit of Mars.

Antares is also of special telescopic interest because it is a binary, with a greenish seventh magnitude companion at a separation of three seconds of arc. The great contrast in magnitudes, however, combined with the rather small separation, makes this a very difficult pair to resolve. The faint green star is easily lost in the glare of its much brighter neighbor, and unless seeing conditions are excellent no telescope will reveal it. For northern observers, in fact, this double is considered more a test of the atmosphere than it is of the optical quality of their telescopes.

TABLE OF OBJECTS IN SCORPIOUS

Double Stars

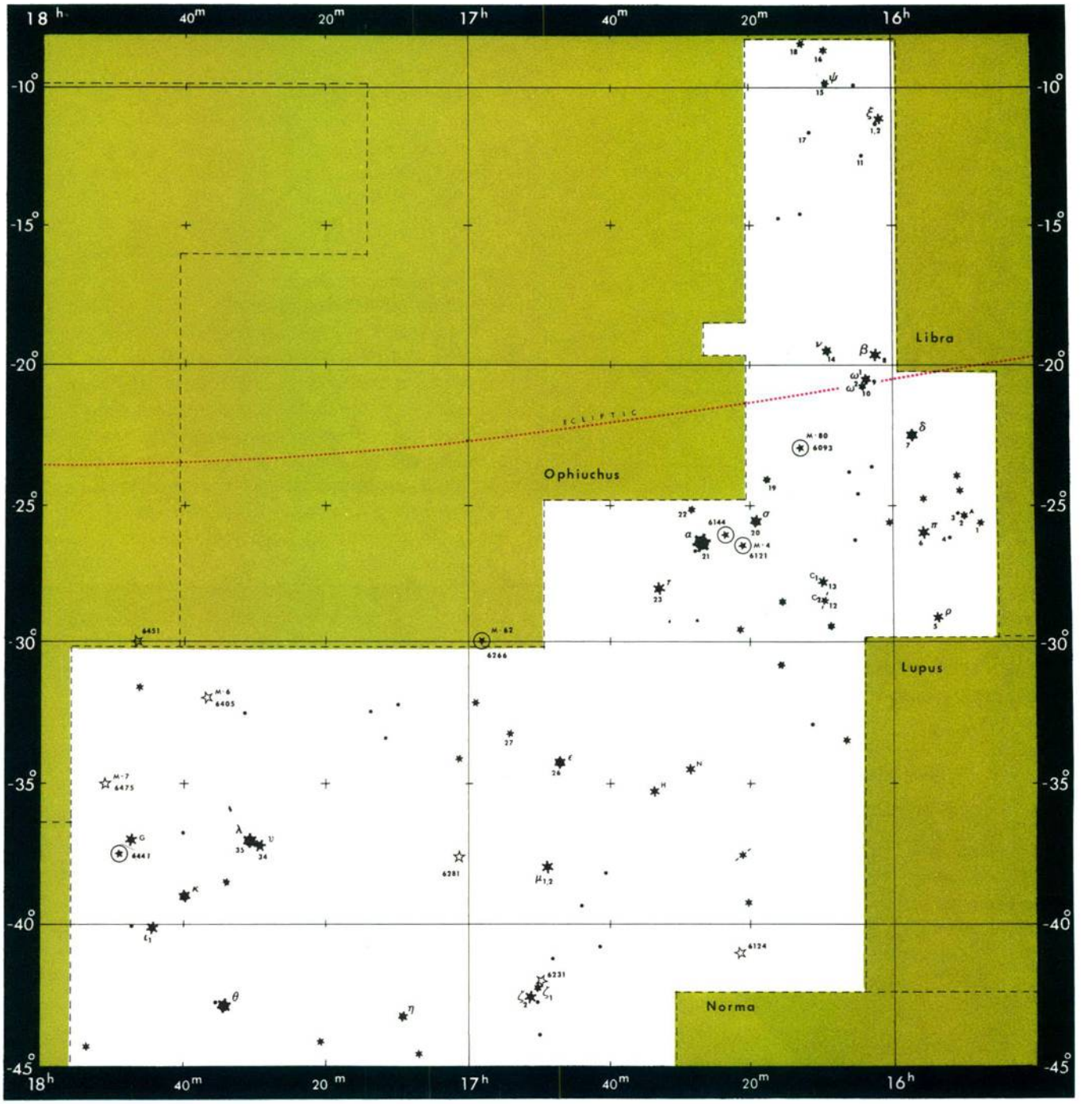
Star	Mag.	Sep.	Colors	R.A.	Dec.
ξ	4.9, 5.2, 7.2	1.2" 7.9"	White-gray	16^h03^m	-11°18'
β	2.9, 8.5, 5.1	0.8" 13.7"	White-blue	16^h04^m	-19°44'
γ	4.2, 6.5	41.0"*	Yellow-orange	16^h10^m	-19°25'
α (Antares)	1.2, 6.8	3.0"	Red-green	16^h28^m	-26°22'

*Both components of this star are close doubles.

Clusters

NGC	Messier Object	Type	Mag.	Size	R.A.	Dec.
6093	M-80	Globular	7	3.3'	16^h15^m	-22°55'
6121	M-4	Globular	6	14'	16^h22^m	-26°27'
6266	M-62	Globular	7	4.3'	16^h59^m	-30°05'
6281		Open	8.5		17^h03^m	-37°51'
6405	M-6	Open	6	25'	17^h38^m	-32°12'
6441		Globular	8		17^h49^m	-37°02'
6451		Open	8.5		17^h49^m	-30°12'
6475	M-7	Open	5	60'	17^h52^m	-34°48'

Epoch 1970



Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula Double Stars Variable Stars

Galaxies Planetary Nebula Open Star Clusters Globular Clusters

Not far from Antares are two globular clusters of greatly contrasting sizes and structures — M-80, a very small, compact cluster, and M-4, which is a very large, loosely structured group.

M-4 is located less than two degrees east of Antares and is such an open globular that the original description in Dreyer's **New General Catalogue** referred to it only as "a cluster". It is easily resolvable in small telescopes, and in a 12 inch reflector at 60x it resembles the rich open cluster M-37, as seen through a six inch scope. A closer look at the center of M-4, however, reveals a more concentrated mass of countless dim stars and shows that its true structure is that of a globular cluster.

M-80, on the other hand, is a much smaller and more condensed cluster; even a 12 inch telescope appears incapable of resolving its stars. In **Celestial Objects for Common Telescopes**, Webb compared it to a comet as seen through a four inch refractor, and added that Sir William Herschel called it "the richest and most condensed mass of stars in the firmament". Lying in a beautiful field halfway between Alpha and Beta Scorpii, M-80 is a striking sight in almost any telescope. And although its true nature can only be seen in large instruments, we can easily imagine the thousands of stars that must be present to make such a small and distant hazy spot so brilliant!

In the area immediately surrounding M-80, we find many other interesting objects and "non-objects". Just east of the cluster, for example, are some apparently blank spots in space where few, if any, stars are seen. Labeled as "starless fields" by the Herschels, Webb described them as "curious vacancies through which we seem to gaze out into an uninterrupted infinity". Actually these are not empty spots at all, but rather places where relatively nearby dust and gas obscure the stars that lie beyond. Far from being holes through which we look out toward the end of the universe, they are in reality regions where our vision is abruptly cut off (see "Between the Stars" in the April issue of ASTRONOMY).

Regardless of their nature, these dark areas are interesting places to spend some time observing. It is senseless to try to describe their exact location, but they will be easily recognizable if you sweep (using low power) back and forth across the region north of Antares and east of M-80. The contrast between star-filled and starless regions will quickly become apparent, and you can spend as much time as you wish tracing out the boundary lines between them.

Also found near M-80 are two prominent double stars which are excellent targets for any size telescope. Both Beta and Nu Scorpii are beautiful wide pairs when viewed with a low power eyepiece, but become complex triple and quadruple star systems when viewed through larger instruments and under higher magnification. Beta's striking white and blue components are easily resolved in a small telescope, but a ninth magnitude star (separated from the brilliant white star by less than one second of arc) is a very difficult test. Similarly Nu appears to consist of two rather widely separated stars under low power, but a four inch scope will split the fainter star into a closer pair, and an eight inch instrument should be effective on the brighter of the two stars.

Scattered generously across the Milky Way as it meanders through the southeastern end of Scorpius are many rich and beautiful open clusters. Although these clusters never rise higher than 20 degrees above the southern horizon for most observers in the U.S., they are certainly well worth your attention. Wait for a night when you can follow the curve of the scorpion's tail all the way to Lambda Scorpii, "the stinger", and then look for G Scorpii, a third magnitude star three degrees to the east. Even in a small telescope you will probably be impressed with G's conspicuous orange color, and pleasantly surprised to find a bright little globular cluster well within the same field of view.

After pausing to examine that very pretty field, you can quickly sweep north to find M-6 and M-7, the area's two most prominent open clusters. M-7 comes first, three degrees north and just slightly east of G Scorpii. This large brilliant cluster will probably completely fill your field of view. It is over 50 minutes of arc in diameter, and its more than 50 stars, ranging from 7th to 12th magnitude, give it a very coarse appearance.

This appearance becomes especially obvious when M-7 is compared to M-6, located just three degrees farther northwest. While M-6 also contains several stars of seventh magnitude (including a red one on its eastern edge), most of its stars are of 10th magnitude or fainter, giving it a much more uniform and quiet look. M-6 has been described as "a butterfly with open wings", and although the appropriateness of such a description depends greatly on the imagination of the observer, it certainly possesses the delicacy of such a gentle creature.

This is one month when space does not permit a full description of all the interesting objects. Especially for observers in southern states, there are many more attractive clusters that have not even been mentioned. Most of us will have to be patient this month and wait for the clearest of skies. But when that perfect night finally does come, our patience will surely be amply rewarded.

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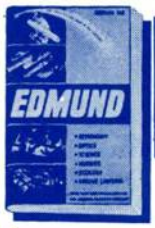

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